Climate is changing: Most climate change models predict shorter, heavier rainy seasons and longer dry seasons—both of which pose very severe challenges to already stretched and under-performing water utilities.

Photo Credit: Virgi Fatmawati/ IUWASH Jakarta
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INTRODUCTION
Climate change represents a complex issue for government and development programs alike, with a diverse group of stakeholders involved, differing conceptual definitions, large volumes of data and associated interpretations, and a wide spectrum of available adaptation options. Despite these complexities, however, it is critical that government agencies and service providers begin to better integrate the climate change variable into planning and investment programs.

Recognizing this important concept, the US Agency for International Development (USAID) incorporated the consideration of climate change adaptation into the scope of work of the Indonesia Urban Water, Sanitation, and Hygiene (IUWASH) Project. In doing so, USAID acknowledged that today’s successes to increase access to clean water will only be sustainable if water utilities and local governments begin consciously planning for a more volatile climate, and, in doing so, put in place the appropriate measures to safeguard their natural and physical assets. Included under Component 2 of the Project—“Capacity improvements to provide sustainable safe water and sanitation services”—the specific programmatic outcome set forth in the terms of reference is as follows: “At least 20 water utilities implementing necessary climate change adaptation measures based on preliminary raw water sources vulnerability assessments.”

In response to the above, this inception report seeks to describe the overall approach of IUWASH to the programmatic integration of climate change adaptation as the Project seeks to increase sustainable access to water supply and sanitation services. More specifically, the report provides the conceptual framework and implementation guidelines for IUWASH’s work with water utilities to bolster resilience to climate change. The report is organized into the following five sections:

- **Section 1** (continued below) briefly introduces the background of the IUWASH Project, including its overarching objectives, geographic scope, and integration of climate change adaptation. The section further provides a succinct summary of the relationship of this work to USAID’s broader climate change and development strategy.

- **Section 2** then provides the context for water resources vulnerability in Indonesia, specifically in the face of climate change. The section considers both challenges faced in the current climate as well as how those challenges may be exacerbated in the face of future climate changes.

- **Section 3** describes the water supply vulnerability assessment and adaptation planning framework that the IUWASH Project employs with water utilities and their stakeholders. More specifically, this section addresses (a) the principles that inform the framework, (b) the steps and sub-steps of the vulnerability assessment process, and (c) the methodology for the selection and prioritization of adaptation options.

- **Section 4** described the various tools that IUWASH uses to support and inform the implementation of the framework, including the PDAM Asset Risk Matrix, geospatial analysis, general circulation models, multi-criteria analysis, and cost-benefit analysis; and

- **Section 5** looks forward to the roll-out the framework as IUWASH seeks to engage a minimum of 20 water utilities in a dialogue concerning climate change vulnerability and potential adaptation options.

Importantly, this inception report does not include a discussion of the application of the IUWASH climate change framework to specific municipalities, as these will be described in separate, dedicated water utility adaptation plans (one per city).
I.1. THE INDONESIA URBAN WATER, SANITATION, AND HYGIENE PROJECT

The USAID Indonesia Urban Water, Sanitation and Hygiene (IUWASH) Project (Contract No. AID-497-C-11-00001) is a 60-month effort designed to support the Government of Indonesia in the achievement of its safe water and sanitation MDG targets by expanding access to these services. The IUWASH Project (or, the “Project”) works with Indonesian government agencies (central, provincial, and local), local government-owned water utilities (PDAMs), sector associations, non-governmental organizations (NGOs), communities, universities, and the private sector. With USAID funding of $33.7 million dollars, the Project is expected to result in the following benefits to Indonesia:

- Two million people in urban areas gain access to improved water supply as a result of US Government assistance;
- 200,000 people in urban areas gain access to improved sanitation facilities as a result of US Government assistance; and
- The per unit water cost paid by the poor in targeted communities decreases by at least 20% through more participatory, transparent, accountable, and financially enabled services.

To contribute to more equitable access, IUWASH emphasizes expanding access among Indonesia’s urban poor; currently those people with the most limited access to these services. To ensure that access improvements are sustained, IUWASH implements activities which contribute to the achievement of three distinct types of intermediate results. These results include:

- Increased demand for safe drinking water access and improved sanitation among urban communities and households with currently unimproved access;
- Improved water and sanitation services provided by the public and private sector institutions in urban areas, with sufficient sustainable capacity to meet increased demand; and
- Improved governance and finances create an enabling environment that supports equitable access to safe drinking water and improved sanitation in urban areas.

Corresponding to the above results are three technical components that together will lead to increased access to water and sanitation services (see graphic at right describing the IUWASH Conceptual Framework). Component One focuses on the mobilization of demand; Component Two aims to increase capacity for service delivery; and Component Three seeks to improve the enabling environment. These components are mutually reinforcing and the outcomes targeted in each are directly linked—success under one component cannot be achieved, in other words, if there is not commensurate success in the other two. Notably, the Project’s work to encourage climate change resilience within the water sector falls under the auspices of Component Two, which focuses predominantly on the operational, technical, and financial performance of water utilities and urban sanitation service providers.
Operationally, IUWASH is a regionally based project supported by a central office in Jakarta and regional offices in Medan, Semarang, Surabaya and Makassar, as well as satellite and liaison offices in approximately 30 other locations. Through this structure, IUWASH aims to assist approximately 50 water utilities and local governments to improve access to safe water and adequate sanitation.

1.2. USAID’S CLIMATE CHANGE AND DEVELOPMENT STRATEGY

It is important to recognize that the inclusion of climate change concerns in the IUWASH Project is not an isolated programming decision, but is in line with the Agency’s broader strategy to integrate climate change into its programs worldwide. As noted in USAID’s 2012 Climate Change Strategy, USAID is seeking to “enable countries to accelerate their transition to climate-resilient, low-emission sustainable economic development” (USAID, 2012). This broader mission is divided into the following three strategic objectives (p. 1):

- **SO 1.** Accelerate the transition to low emission development through investments in clean energy and sustainable landscapes;
- **SO 2.** Increase resilience of people, places, and livelihoods through investments in adaptation; and
- **SO 3.** Strengthen development outcomes by integrating climate change in Agency programming, learning, policy dialogues, and operations.

The work described herein falls under both SO 2 and SO 3 given its focus on water utility adaptation as well as being part of larger Agency investment in the water sector. Regarding the former, USAID describes climate change adaptation efforts as those that, “help protect existing investments from climate change, maintaining development gains and contributing to economic security” (p. 15). The adaptation capacity of local partners such as water utilities is, of course, multifaceted, and thus efforts to shore up this capacity may include improved understanding of climate change as a whole, analysis of institutional vulnerabilities, ability to integrate climate change into long-term planning scenarios, as well as the capability to respond to evolving threats. Also, as the USAID strategy mentions, scientific knowledge alone is insufficient to adequately respond to climate change, but must be accompanied by “effective governance systems” consisting of “sound regulations and policies as well as effective institutions and processes to draft, implement, monitor, and enforce them” (p. 16). This emphasis on governance complements IUWASH’s technical approach, which specifically seeks to improve the governance processes supporting the water and sanitation sector.

Concerning Strategic Objective 3, the inclusion of climate change under IUWASH represents a good example of how USAID can integrate climate change into Agency programming. Indeed, Chapter IV of USAID’s Climate Change Strategy cites water supply, sanitation, and hygiene activities as a prime opportunity for the integration of climate change themes into USAID’s work on the ground. Specifically, the document notes that, “The effective planning and management of water and sanitation systems requires anticipating the potential effects of both climate-related stressors, such as less predictable rainfall and water flows, and non-climate stressors such as population growth [and] pollution” (p. 19). Given that climate change mainstreaming into WASH programming remains in its infancy, the technical assistance under IUWASH described in this report represents an important opportunity to learn what types of approaches and tools work best on the ground. Thus, our expectation is that the lessons learned by IUWASH and USAID-Indonesia can be more broadly applicable to similar USAID projects outside Indonesia, thereby supporting USAID’s efforts to instill resilience in the WASH sector worldwide.
WATER RESOURCES AND CLIMATE CHANGE IN INDONESIA
Indonesia faces serious environmental threats on many fronts as a result of rapid but poorly managed economic development and population growth. These environmental problems constitute fundamental challenges to Indonesia’s water resources security. Widespread land use change has reduced the infiltration potential of rainfall into the soils of deforested and urban lands, leading to declines in groundwater levels. Increasing amounts of rainwater that have historically recharged subsurface aquifers now flow over the land surface as runoff. This has generated an increase in floods, soil erosion and sedimentation, landslides, water logging, crop damage, water contamination, and damage to infrastructure.

Waste from sanitation systems and untreated industrial pollutants directly contaminate raw water resources. Flooding can disturb and release contaminants from industry, agriculture and domestic waste (overflowing septic tanks, rubbish sites). Increased soil erosion can produce higher levels of total suspended solids, salts and contaminants. Thus, higher runoff and soil erosion rates contribute to degraded water quality. Excessive sedimentation can disturb ecosystems, affect river courses and flow rates, and reduce the storage capacity of standing water bodies.

Poor management and lack of adequate infrastructure mean that more than 50% of Indonesia’s water demand is currently being met by groundwater from subsurface aquifers (BAPPENAS, 2010). Because this water resource is not sufficiently replenished, the practice is unsustainable. Furthermore, many urban environments, including Jakarta, are experiencing alarming rates of land subsidence due to over-extraction of groundwater. This has led to an increase in the frequency and degree of flooding, and damage to existing infrastructure. Moreover, declining water tables have allowed further intrusion of saline water into potable groundwater supplies. Leaking septic tanks and other sources of contaminants are also degrading the quality of the remaining available groundwater.

2.1. INCREASING THREATS

The threat to Indonesia’s water resources security is expected to be exacerbated by the impacts of climate change. This section outlines how Indonesia’s climate has already changed, is projected to change in the future, and will further harm water resources security.

2.1.1. TEMPERATURE

Indonesia has experienced an average surface air temperature increase of roughly 0.5°C in the 20th century (BAPPENAS, 2009), or 0.3°C since 1990 (World Bank, undated). Indonesia’s average temperature is projected to increase, relative to the 1961-1990 baseline period, by between 0.8°C to 1.0°C during 2020-50 (BAPPENAS, 2010); and between 2.1°C and 3.4°C by 2100 (Boer and Faqih, 2005, Rataq, 2007). The temperature increases will vary depending on the island or region and also on the season, possibly by as much as 2°C (BAPPENAS, 2009). Rising temperatures translate into higher evaporation rates, crop stress, and prevalence of waterborne diseases.

2.1.2. RAINFALL

Indonesia has experienced a decline in annual rainfall in the southern regions and an increase in precipitation in the northern regions (World Bank, 2011). Overall, there has been a general decrease in annual rainfall during recent decades (Aldrian, 2007). Precipitation seasonality has shifted so that the wet season rainfall in the southern region has increased while the dry season rainfall in the northern region has decreased. However, continued climate change is predicted to result in 2% to 3% more rainfall per year in Indonesia (Rataq, 2007, Susandi, 2007). In fact, much of Southeast Asia has experienced a decrease in annual rainfall, but this trend is expected to reverse by mid-century. The expected future trend is that...
Indonesia’s dry seasons will last longer while the wet seasons will be shorter and more intense (Figure 1), leading to a significant increase in the risk of drought, flooding and erosion (Rataq, 2007, BAPPENAS, 2009) as well as reduced infiltration into aquifers. Increased flooding could exacerbate the risk of water resource contamination and risks to human life, property and infrastructure unless action is taken to reduce these risks. Higher soil erosion rates may alter raw water flow systems and the storage capacity of standing bodies. The number of landslide events is likely to rise in parallel with increased erosion, precipitation and runoff.

2.1.3 EXTREME WEATHER

As illustrated in Figure 2, extreme weather events in Indonesia are already escalating (Boer and Perdinian, 2008) and weather patterns are likely to become harder to predict. The incidence of flooding is predicted to continue rising, as a result of shorter but more intense rainfall (Rataq, 2007, Susandi, 2007). Higher temperatures during longer dry seasons will increase the risk of forest fires. Changes in wind speed and direction, air pressure, cloud formation, ocean currents, temperatures and sea surface levels are likely to give rise to more severe storms and cyclones. Coastal areas are particularly at risk from these phenomena.

A characteristic of climate change in the Asia-Pacific region is its magnifying effect on ENSO (El Niño Southern Oscillation) events (BAPPENAS, 2009). An ENSO event typically persists for a period of 0.5-2 years (BAPPENAS, 2010). The well-known oscillation between the El Niño and La Niña climate systems is predicted by most climate models (see box) to become more frequent, intense and sustained (BAPPENAS, 2009). In general terms, a La Niña event brings significantly higher levels of rainfall (floods) and lower temperatures while El Niño causes higher temperatures and lower rainfall (drought) (see Figure 3). Indonesia’s weather is particularly influenced by ENSO and is therefore highly vulnerable to more extreme fluctuations. Similarly, the Indian Ocean Dipole system, which has a greater influence on far western Indonesia (North Sumatra) than does ENSO, may also exhibit a greater amplitude and longer frequency (DNP, 2010).
2.1.4. SEA LEVEL RISE

A 1 to 9 mm per year sea level rise has been observed in many locations since the mid-1980’s (SME (KLH), 2007a). The Intergovernmental Panel on Climate Change (IPCC, 2007) predicts sea levels will continue to rise 1.3 (±0.7) mm per year over the next several decades. In contrast, some models project a 6 to 8 mm per year rise in the sea level in Indonesia, producing an increase of roughly 195 mm by 2030, 320 mm by 2050, and 700 mm by 2100 (BAPPENAS, 2010). Indonesia could lose hundreds of its smaller islands as a result of climate change (SME (KLH), 2007a). Many urban centers simultaneously experience alarming rates of land subsidence due to groundwater overdraft. For instance, Jakarta’s land surface is sinking several centimeters per year – up to around 30 cm per year in some regions and at least 12 cm per year in coastal parts of North Jakarta (Djaja et al, 2004). As sea levels continue to rise, these lands will be inundated (UNDP, 2007). ENSO events have been correlated to higher wave activity of 2-5 meters along the coasts, which may be intensified due to global warming. Higher sea levels directly threaten millions of people living along coastlines throughout the archipelago, major cities, industries, agriculture, fresh water coastal ecosystems, as well as productive groundwater aquifers and fertile soils due to saline groundwater intrusion.

Figure 2: Occurrence of climate-related hazards in Indonesia, 1950-2005 (Boer and Perdinian, 2008)

Modeling Climate Change

As discussed in greater detail in Section 3, numerical models (General Circulation Models or GCMs), representing physical processes in the atmosphere, ocean, cryosphere (ice-covered areas) and land surface, are the most advanced tools currently available for simulating the response of the global climate system to increasing greenhouse gas concentrations. While simpler models have also been used to provide globally- or regionally-averaged estimates of the climate response, only GCMs, possibly in conjunction with nested regional models, have the potential to provide the geographically and physically consistent estimates of regional climate change that are required in impact analysis. GCMs depict the climate using a three-dimensional grid over the globe, typically having a horizontal resolution of between 250 and 600 km, 10 to 20 vertical layers in the atmosphere and sometimes as many as 30 layers in the oceans. Many physical processes cannot be modeled accurately and therefore some uncertainty exists, and GCMs may simulate quite different responses to the same forcing, simply because of the way certain processes and feedbacks are modeled.

(http://www.ipcc-data.org/ddc_scen_selection.html)
2.2. CLIMATE CHANGE IMPACTS

Figure 41 below presents the distribution of water over the Earth’s surface. The following presents a brief overview of the potential impacts of climate change on each of these resources.

2.2.1. SURFACE WATER (STREAMS, LAKES, DAMS)

As temperatures increase due to climate change, surface raw water resources (streams, lakes, dams) will experience higher evaporation rates. Evaporation reduces the quantity of raw water but can also push the raw water body below the threshold of intolerable or untreated quality by effectively concentrating contaminants. Plants and animals require more water to survive, reducing the water supplies available to human populations. Higher temperatures also promote faster growth of disease-giving waterborne organisms, adversely affecting raw water quality.

Higher amounts of rainfall over shorter time periods will increase the amount of surface runoff generated during a rainfall event. However, this does not usually translate into enhanced raw water availability. An increase (in magnitude and frequency) in extreme flooding events could breach or break more dams, continue to alter river courses, cause more damage to water infrastructure, and lead to the contamination of surface water bodies. Increased runoff tends to generate higher soil erosion and sedimentation rates. This may, in turn, degrade water quality (total suspended solids, salinity and contaminants) and reduce the amount of raw water stored by changing the geometry of surface water bodies.

During the more severe ENSO events that are predicted for Indonesia’s future climate, the degree of flooding and drought, and their impacts, may be amplified. Sea level rise will inundate coastal areas by several meters in some extreme weather conditions. This threatens coastal raw water supplies as well as water supply infrastructure.

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2.2.2. GROUNDWATER

Groundwater systems are typically more resilient to climate change than surface water bodies and thereby offer significant opportunities for climate change adaptation (Clifton, 2010). Nevertheless, groundwater supplies are threatened in a variety of ways by Indonesia’s changing climate. As standing bodies lose more water due to higher evapo-transpiration rates, more groundwater may naturally discharge into the standing bodies to balance the surface water losses (a change in hydraulic head).

Higher temperatures also mean crusting of soils will occur faster and to a greater extent, causing soils to require more time to return to maximum rainfall infiltration conditions, thus reducing the total volume of water added to groundwater supplies. On the other hand, higher annual rainfall can result in more groundwater recharge. However, since maximum infiltration rates are typically reached relatively quickly during (typical) rainfalls, heavier precipitation does not usually increase the volume of recharging groundwater in Indonesia’s climate but increases runoff which will wash away the valuable topsoil. Moreover, an increase in groundwater recharge is not always desirable in all locations because in extreme cases it could lead to contamination, landslides, water logging and groundwater mixing. Floods can deposit large volumes of soil or fine sediments, reducing recharge potential by clogging or thickening infiltrating interfaces. Floods can also lead to the disturbance and transport of contaminants or pollutants that negatively affect the quality of groundwater (through unprotected bore holes). Sea level rise (transgression) can cause intrusion of saline groundwater further inland into aquifers, contaminating more potable water.

2.3. INDONESIA’S WATER RESOURCES AND CLIMATE CHANGE

Indonesia has a very low adaptive capacity to climate change. More than 50% of the population lives below the poverty line of US$2 a day², making them highly dependent on others for support. Unfortunately, it is typically Indonesia’s poorest people that are most vulnerable to climate change due to their high dependency on the environment, their high exposure and sensitivity to climate-related hazards, and the prioritization of other development objectives. Furthermore, the government is not yet contributing significantly to climate change programs (mitigation or adaptation) due to lack of resources and limited familiarity with the science and urgency of the situation. The Government of Indonesia’s (GOI) planning, funding and implementing agencies, as well as local governments (PEMDA) and PDAMs, lack comprehensive technical or scientific understanding of water resources security planning, advanced hydrological/hydrogeological concepts, and their relation to climate change. This makes it difficult to develop and enforce policies for responsible development and climate change adaptation, and to strengthen the (local) institutions already addressing these issues.

People living in rural areas, particularly farmers, usually have more direct experience with current climate change impacts than do those in urban areas. This typical disconnection between the decision makers and those already affected by climate change inhibits progress. The frequency of natural disasters in Indonesia is rising (Figure 2), but, as discussed later in this report, it is often difficult to distinguish the contribution from climate change vis-à-vis the effect of other environmental factors such as deforestation.

² See: http://www.usaid.gov/locations/asia/countries/indonesia
Indonesia has more than 80,000 kilometers (UNDP, 2007) of coastline around its thousands of islands and a high proportion of the population lives near the coast. This translates to a higher vulnerability to the impacts of sea level rise, saline intrusion into aquifers, storms and coastal flooding (rob). Indonesia’s low tropical latitude and position on the Pacific ‘Ring of Fire’ subjects it to an extremely high number of natural disasters each year. Consequently, a relatively large proportion of funding is spent on disaster relief and infrastructure repair at the expense of preemptive natural disaster resilience projects (including those linked to climate change).

The quality and quantity of the available climate, disaster, land use and water resources data is poor. This is due to limited or non-existent data collection and record keeping systems by government departments and PDAMs. Data cannot be collected because the government either does not have access to appropriate measuring instruments and laboratories (or training), or does not have a centralized (electronic) record keeping system. In some case, sources of good quality water are not considered due to cost or other factors.

PDAMs typically incur large losses due to high non-revenue water (NRW), which often goes unreported. Many PDAMs in Indonesia have NRW at around half of total produced water. High NRW due to leaks, inefficiency and illegal use of water is a major factor in reducing the PDAMs’ capacity to expand their operations or tackle climate change because they frequently operate at a financial loss.

As discussed in Section 3, climate change adaptation work in Indonesia is in its infancy, with only a small number of organizations (stakeholders) currently working in this field. Usually, climate change science is ignored or not understood by government departments, and relevant data is often either misinterpreted or unavailable. Stakeholders include domestic and foreign government ministries, departments and organizations; the private sector; research groups; donors and NGOs. Appendix A provides an analysis of all stakeholders working in climate change adaptation and/or water resources management in Indonesia. Appendix B presents a summary of progress through early 2012 with relevant stakeholders. It should be noted that some positive progress is also being made in climate change mitigation programs in the forestry sector and geothermal energy projects. However, those projects are not included in Appendix A or Appendix B.

### 2.4. MEETING THE CHALLENGE

Climate change adaptation work in Indonesia is in its infancy, with only a small number of organizations (stakeholders) currently working in this field. Usually, climate change science is ignored or not understood by government departments, and relevant data is often either misinterpreted or unavailable. Stakeholders include domestic and foreign government ministries, departments and organizations; the private sector; research groups; donors and NGOs. Appendix A provides an analysis of all stakeholders working in climate change adaptation and/or water resources management in Indonesia. Appendix B presents a summary of progress through early 2012 with relevant stakeholders. It should be noted that some positive progress is also being made in climate change mitigation programs in the forestry sector and geothermal energy projects. However, those projects are not included in Appendix A or Appendix B.
WATER SUPPLY VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING APPROACH
Moving from the country context in Chapter Two, the third chapter of the Inception Report turns to the IUWASH methodology for assessing climate change vulnerability among PDAMs and the development of adaptation plans. Section 3.1 discusses the principles and assumptions that underlie the overall approach. Section 3.2 then describes the four-step Vulnerability Assessment and Adaptation Planning Framework for water supply (VAAP Framework, or the “Framework”).

3.1. GUIDING PRINCIPLES AND ASSUMPTIONS

Prior to delving into the steps of the water supply VAAP Framework, it is first useful to outline the broader principles that informed the development of the Framework and will further guide its implementation over the course of IUWASH:

(a) Climate change is not an isolated issue or separate field of expertise, but a source of risk that is inextricably linked to the way utilities and the communities they serve use and manage water and land resources. It is thus best approached in an integrated manner, building off of and contributing to the utility’s and local government’s broader planning efforts. To the maximum extent possible, then, IUWASH convenes a broad set of stakeholders to discuss the implications of climate change for each jurisdiction’s water resources, striving to integrate the risks posed by climate change into water security planning for each municipality. In this regard, climate change will likely exacerbate current raw water security risks posed by economic development, population growth, and urbanization, and thus must be considered in conjunction with what is presently happening on the ground. This approach is in line with the conclusion of the IPCC that adaptation measures are rarely (if ever) undertaken in response to climate change alone⁴. Our approach is also embodied by the Economics of Adaptation Working Group, as demonstrated in the quotation at right. Practically speaking, this principle also means that we will draw not only on experts in hydrology and water resources, but also on experts in the fields such as finance, economics, planning, public policy, and engineering as we work with utilities to develop adaptation strategies.

(b) The IUWASH Water Supply VAAP Framework uses a “bottom-up” approach that focuses on what is known about the current environment and how the water system may be sensitive to climate change. As noted by the US Environmental Protection Agency (2010), there are, essentially, two approaches to conducting vulnerability assessments for water utilities: top-down modeling assessments and “bottom-up” threshold analyses. The former approach relies largely on a cascade of global climate models, regional (downscaled) climate models, watershed hydrological models, and water system pressure models. By its very nature, a top-down approach is research and data intensive, making it less practical for regions where extensive historical data and modeling capacity are not available. Alternatively, under the “bottom-up” approach, “the most critical vulnerabilities of of a district’s water supply system are identified, the causes of those vulnerabilities are articulated, and then steps are taken to better address and solve the vulnerability in the face of climatic uncertainty” (EBMUD, 2009). Stated differently, a bottom-up approach emphasizes the use of local knowledge gathered through interviews, focus-group discussions, and stakeholder workshops and informed by science-based analysis. Water utility managers in Indonesia, for example, are familiar with the flow patterns and vulnerabilities of their raw water resources as they have been adapting to changes in raw water availability for years, meaning they generally have the best understanding of what works and what does not work.

“...The key question [when managing climate risk] is not, “How can we minimize the damage from climate hazards?” but rather “How can we reach out development targets while accounting for current and future risks?”

~ The Economics of Climate Adaptation Working Group

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Notably, a bottom-up approach is not meant to diminish the importance of science-based analytics. Indeed, as noted in the previous chapter, current fluctuations in surface water flow are likely to become increasingly severe, requiring a new level of water security planning. This is where science-based tools such as global circulation models (GCMs) can play an important role to construct and visualize future climate scenarios, informing the perspectives of utility managers and other government stakeholders as they develop various “what-if” scenarios.

(c) To focus the vulnerability assessment and adaptation planning process, the IUWASH Water Supply VAAP Framework distinguishes between a utility’s natural assets and infrastructure assets (also referred to as “constructed” or “built” assets). Natural assets include, for example, groundwater (the existing water table), aquifers, springs, rivers and lakes, as well as the broader health of the local watershed. Infrastructure assets are the built structures that draw from these natural assets and deliver clean water to customers. Examples of constructed assets include intakes, wells, water treatment plants, reservoirs, distribution pipelines, as well as administrative offices. As discussed in Chapter 2, the decline of natural assets represents arguably the greatest threat to expanded access to water supply services in Indonesia today, thus receiving a particularly strong emphasis in the Framework. Given the likely risks posed by increased flood events, however, it is also important that infrastructure vulnerabilities be incorporated into the planning process such that PDAMs actively consider potential climatic risks as they plan new infrastructure investments.

Closely related to the distinction between natural and constructed assets is the consideration of supply and demand. First, it is important to understand the extent to which a PDAM’s natural and constructed assets are able to meet demand under current climatic conditions, particularly in light of population growth, coverage targets, and economic growth. Then, after considering the types of threats to natural and constructed assets posed by climate change, we can develop scenarios to how supply and demand might change over time accompanied by appropriate measures to respond and adapt to those changes.

(d) The vulnerability assessment and planning process itself is a means of learning, collaboration, and capacity-building. In other words, it is not just about “making another plan,” but thinking and learning in a collaborative manner with PDAMs, local governments, and supporting stakeholders on how to better plan for a highly variable future. As such, the vulnerability assessment and adaptation planning process itself represents an important opportunity for building local capacity. In this regard, IUWASH also partners with local entities—particularly local universities—to assist in conducting the vulnerability assessments. Not only does the engagement of universities allow the Project to access an important source of local knowledge, it also begins to build the capacity of secondary education institutions to conduct such assessments independently. A similar approach has been utilized in the United States, where water utilities frequently partner with universities to assist in evaluating climate change risks. Iuwash engages local universities in the vulnerability assessment process, tapping an important source of local knowledge and, importantly, building local capacity to evaluate and respond to climate change risk.

(e) Vulnerability assessment and adaptation planning must be conducted on an iterative basis. Knowledge concerning the impacts of climate change continues to evolve as awareness grows and research efforts are intensified. Further, as more and more water service providers begin to implement climate change adaptation measures, important lessons will emerge concerning what works and what does not. Thus, the evaluation of climate change threats and the development of appropriate response measure should always be viewed as an iterative process. In this regard, we are encouraging water utilities to integrate vulnerability assessment and adaptation planning into their five-year corporate planning process, thereby ensuring that adaptation plans are regularly updated, financed, and implemented.
3.2. WATER SUPPLY VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING FRAMEWORK

Building off of the principles discussed above, IUWASH developed the Water Supply Vulnerability Assessment and Planning Framework to serve as a conceptual guide during the implementation process with each PDAM partner. Table 1 below summarizes the four phases and associated steps that make up the Framework. Sub-sections 3.2.1 through 3.2.4 address each step in greater detail, with the supporting tools described in the following chapter.

3.2.1. EVALUATION OF THE CURRENT SITUATION – THE BASELINE SCENARIO

Prior to attempting to assess climate change risk to water utility’s natural and constructed assets, it is first necessary to fully understand the current context, including characteristics of the existing water supply system as a whole (supply-side), the nature of the customer base (demand-side), the development objectives of the utility, and the existing threats to the utility’s assets. Regarding this final point, it is important to recognize that the natural and built assets of water utilities in Indonesia are already facing a variety of serious risks even in the current climate. Importantly, while risks such as deforestation are independent of climate conditions, changes in the climate will undoubtedly only exacerbate such “baseline” risks. Specific steps under the first phase of the Framework are as follows:

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<th>Phases</th>
<th>Steps</th>
<th>Tools/Methodologies</th>
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<tbody>
<tr>
<td>2. Climate Change Vulnerability Assessment: The Climate Change-Driven Scenario</td>
<td>a. Analysis and synthesis of localized climate change data using existing research, interviews, and models; b. Development of Climate Change-Driven Scenario: Using quantitative and qualitative information to envision future impacts; c. Climate Change-Driven Scenario Vulnerability Assessment: Considering how the PDAM’s risk profile may change.</td>
<td>Geospatial Analysis, General Circulation Models, PDAM Asset Risk Matrix, Stakeholder Workshop</td>
</tr>
</tbody>
</table>
(a) Stakeholder Engagement. To formally launch the vulnerability assessment and adaptation planning process, the IUWASH team convenes a stakeholder kick-off meeting to discuss the process with the water utility and the local government. Important aspects of the initial stakeholder meeting include: identifying the expected outputs and results from the assessment, defining roles and responsibilities, discussing data availability, and understanding the medium and long-term objectives of the utility and its local government owner. Concerning this last point, it is critical that IUWASH fully understand the development objectives of the utility, particularly if they are considering significant service expansion in the coming years and will be considering alternative water sources.

As part of the initial stakeholder engagement process, IUWASH also requests that the PDAM form an internal climate change working group to act as the institutional owners of the vulnerability assessment and adaptation planning process. Ideally, the establishment of such a working group and the nomination of the chairperson should be formalized under a Decision Memorandum from the President Director of the water utility.

(b) Data Collection and Analysis. Data collection and analysis is vital to understanding the current situation. Basic data requirements focus on general areas such as meteorology, hydrology, and demand, which may be potentially affected by climate change. In general, data and information for each evaluated PDAM is collected in the following areas:

- Natural assets including surface water resources and groundwater resources (springs and deep wells), including the quantity and quality of available raw water associated with each asset;
- Geology, hydrology, hydrogeology, topography, land use, and pollution sources for each of the PDAM catchment areas;
- PDAM infrastructure assets including intakes, water treatment facilities, storage facilities, transmission and distribution pipelines, and administration buildings;
- Historical hazards to the PDAM’s water resources, including flooding, landslides, sea level rise, salt water intrusion, storm surges, and drought data. This information would include but not be limited to the extent of damage, costs incurred, areas affected, and programs put in place by the PDAM to prevent damage from occurring in the future;
- Long-term and short-term data from weather stations within the service area of the PDAM; and
- Current and projected population and demand, as well as customer usage levels.

Sources of data and information include not only the PDAMs themselves, but also governmental agencies such as BAPPENAS, National Council on Climate Change, Ministry of Public Works, Ministry of Environment, Ministry of Forestry, Ministry of Energy/Mineral Resources, and BMKG. Further, potential sources of information among donors include: the ADB (Water Resource Project), PAKLIM/GIZ, Mercy Corps, AusAID, and the World Bank.

For the initial data collection, organization, and analysis associated with each vulnerability assessment process, IUWASH establishes a partnership with a local university (wherever a suitable institution is available and interested to join this program). Given their familiarity with the local context and existing research capacity, universities are generally well positioned to take on this role. Indeed, a limited number of universities (in Jakarta and Yogyakarta) have already established climate change programs, and working with a utility in this manner would further build their capacity and enable them to act as a resource on a long-term basis. An illustrative scope of work for this role is included in this report as Annex B.

Notably, an important element of the preliminary data analysis will be the development of a supply and demand projection in light of the PDAM’s current capacity and customer base. The purpose of this projection is to understand the extent to which the PDAM may already be facing supply gaps from its current natural assets given the growing needs of the community.
(c) Baseline Scenario Vulnerability Assessment. Utilizing the historical and current hazards identified during the data collection, the final step under Phase 1 is the development of the vulnerability assessment for the baseline scenario which estimates the level of risk to the PDAM’s natural and constructed assets in the current climate. As noted in the opening paragraph to this section, PDAM assets are already threatened by a broad spectrum of existing hazards, including flooding, drought/water-stress, landslides, and sea level rise. With the exception of sea level rise, these hazards may be caused by unsustainable economic practices (i.e. environmental degradation), climate change, or; more likely, a combination of both.

To construct the baseline risk scenario, then, IUWASH and the water utility employs two tools: geospatial analysis and the PDAM Asset Risk Matrix. Concerning the former, geographic information systems (GIS) will be used to map historic and ongoing risks, thereby helping to spatially identify risk “hotspots.” Regarding the Asset Risk Matrix (ARM), this semi-quantitative tool uses conversion, population growth, channelization of rivers, construction of assets in the floodplain, weak decision-support systems, absence of emergency communication systems, etc.

- Third, building upon the notion of multiple drivers, even when the causes of increased vulnerability to certain hazards appears to be obvious, there may well be underlying reasons that are not well understood. For example, while upper watershed deforestation may appear to be the clear direct cause of increased flooding in a watershed, the deforestation itself may actually be linked to localized warming trends which are forcing farmers to shift their crops to higher elevations. Thus, climate change would then be considered an indirect driver of flood risk, although this could only be determined after gathering extensive information from farmers concerning changes in growing patterns.

The bottom line, then, is that climate change tends to make existing vulnerabilities that much worse, which argues for a holistic approach to addressing all sources of risk. Further, rather than looking backwards at historical data and attempting to discern what problems were primarily driven by climate change as opposed to other factors, vulnerability assessment and adaptation planning is best approached from a forward-looking perspective. In other words, adaptation planning asks the question, “Given what we know about our current risks combined with the likelihood of increases climate variability, how do we best plan for the future?”

---

But is the problem actually climate change?

When constructing a baseline risk scenario (or, for that matter, the climate change-drive risk scenario) there is a temptation to attempt to discern what proportion or aspect of the risks identified are already due to changes in the climate (versus other causes such as rapid urbanization). Attempting to “disentangle” the negative impacts of climate change and land use practices, however, is often an impossible task. While there many reasons for this, three stand out:

- First, in the absence of meticulous meteorological and hydrological records, it is very difficult to quantify the extent to which a local climate has actually changed, and, by extension, how these changes have influenced local hydrological processes. Only by gathering extensive data from multiple data points, in other words, can we firmly establish the precise rate of change. What’s more, where climate variation is already visible, it is nearly impossible at this point to discern the extent to which it is due to anthropogenic causes (i.e. greenhouse gas emissions) versus natural climate variability. While this judgment will likely become easier as the impact of emissions intensifies over time, further advancements in modeling combined with more robust data sets will be required.

- Second, for every hazard risk identified, there are almost always multiple “drivers,” of which climate variability is often just one. Vulnerability to flooding, for example, may well be due in part to increased precipitation (i.e. climate change), but is also likely caused by other drivers such as upstream land-use conversion, population growth, channelization of rivers, construction of assets in the floodplain, weak decision-support systems, absence of emergency communication systems, etc.

The bottom line, then, is that climate change tends to make existing vulnerabilities that much worse, which argues for a holistic approach to addressing all sources of risk. Further, rather than looking backwards at historical data and attempting to discern what problems were primarily driven by climate change as opposed to other factors, vulnerability assessment and adaptation planning is best approached from a forward-looking perspective. In other words, adaptation planning asks the question, “Given what we know about our current risks combined with the likelihood of increases climate variability, how do we best plan for the future?”
probabilistic risk analysis to estimate and rank the PDAM’s natural and constructed assets according to the level of perceived risk. Both geospatial analysis and the Assets Risk Matrix are described in greater detail in the following section (3.3), including the presentation of illustrative results.

Notably, the basic objective of the baseline risk scenario is to develop an overall profile of the risks facing the water utility’s natural and built assets. Further, while the general sources of the risk will be identified, IUWASH does not attempt to ascertain which risks are already due to changes in the climate as opposed to other unsustainable practices such as unplanned urbanization or upstream deforestation. Indeed, as the text box below notes, it is often impossible to accurately determine the extent to which a risk is due to climate change or other anthropogenic causes.

3.2.2 CLIMATE CHANGE RISK ASSESSMENT – THE CLIMATE CHANGE-DRIVEN SCENARIO

The second phase of the IUWASH Vulnerability Assessment and Adaptation Planning Framework introduces the variable of climate change, considering the manner in which the baseline risk scenario may be altered by anticipated fluctuations in temperature and precipitation. The fundamental challenge with distilling climate change risk is, of course, the high level of uncertainty that currently surrounds climate projections, even over the short and medium term. As Chapter 2 discusses, there are certainly broad, country-wide predictions of how temperature and precipitation may change in the upcoming decades. As local climate is subject to such a large number of variables, including local topography, proximity to major bodies of water, and density of development and urbanization. This uncertainty should not be cause for inaction, but is simply important to bear in mind as a PDAM seeks to assess climate change risk. Additionally, the level of local uncertainty concerning climate change impacts makes understanding current climate vulnerabilities—i.e. the baseline scenario—all the more important, as it provides a foundation from which to construct forward-looking “climate-change informed” scenarios.

Overall, then, there are three principal steps to the climate change risk assessment phase: (a) analysis and synthesis of localized climate change information, (b) construction of a “climate-change” driven scenario, and (c) assessment of how current risks will be modified, exacerbated, or even diminished by climate change. The steps are described in greater details below.

(a) Analysis and synthesis of localized climate change data. The first step of the climate change risk assessment phase is to catalogue, analyze, and synthesize existing information on how the local climate may change in the coming decades. There are three key sources for this information that IUWASH and its PDAM partner consult when summarizing the current thinking concerning localized climate change impacts:

- **Existing Research and Literature Reviews.** As discussed under Chapter 2, there is an ever-increasing body of research concerning how the climate may change in Indonesia, including, to some extent, at the regional level. The National Council on Climate Change, for example, has already performed a vulnerability analysis for the Province of North Sumatra, which includes projected changes in temperature and precipitation down to the kota and kabupaten level. Bappenas and the Asian Development Bank have also carried out considerable climate change analysis in West Java for the water sector. Where available, such research represents a time-efficient means to obtain a background on regional climate projections and build from analysis completed by international and domestic entities.

- **Expert Interviews and Focus Group Discussions.** Tapping local expertise represents an important means of obtaining qualitative inputs on climate change projections. This may be done by, for example, conducting a series of expert interviews in the local academic arena as well as through focus group discussions with knowledgeable stakeholders. In this regard, beyond discussions with water utility staff, the farming community also represents a logical group to meet with to discuss climate trends.

- **Climate Change Models.** General Circulation Models (GCMs) represent a third source of information to develop “what-if” climate scenarios.
Discussed in greater detail in the following chapter, IUWASH primarily relies upon the USAID supported “Climate 1-Stop Portal” as the World Bank’s Climate Change Knowledge Portal.

While each individual source inevitably brings biases and assumptions, drawing on a variety of institutions, individuals, and models will help to mitigate such predispositions and provide a “big picture” perspective of climate change trends in the region. As noted in the by the IPCC in the quotation at right, a balance of quantitative and qualitative sources also helps to more fully capture the complexity of climate change vulnerability, as important issues can emerge from face-to-face discussions that the numbers may not always show.

Quantitative approaches for assessing vulnerability need to be complemented with qualitative approaches to capture the full complexity and the various tangible and intangible aspects of vulnerability in its different dimensions.

~ IPCC, 2012 (p 91)

(b) Development of Climate Change-Driven Scenario(s). Using the quantitative and qualitative information gathered from the literature, local consultations, and climate change models, IUWASH then works with the PDAM to construct one to two climate change-driven scenarios (CCDS) that will serve as reference points for adaptation planning. The use of scenarios is, essentially, a means of helping to address the considerable uncertainty associated with climate change projections.

The Economics of Climate Change Working Group (2009) adopted a scenario-based approach to assess climate change vulnerability in eight countries around the world, developing both “moderate climate change” and “high climate change” scenarios for each locale (in addition to a “today’s climate” scenario). Under the Water Supply Vulnerability Assessment and Adaptation Planning Framework, IUWASH works with the utility to determine whether, practically speaking, more than a single scenario is needed. It may be sufficient, in other words, to simply construct one “moderate-change” scenario, recognizing the equal likelihood that the severity of change may be more or less. Further, we also emphasize medium-term planning timelines (2020 to 2050) as opposed to attempting to construct what-if scenarios for longer term timelines (beyond 2050).

(c) Climate Change-Driven Scenario Vulnerability Assessment. Based upon the climate-change driven scenario(s), IUWASH and the PDAM then review the vulnerability maps and PDAM Asset Risk Matrix prepared for the baseline (current climate) scenario and consider how the anticipated changes will exacerbate (or diminish) the identified risks. More specifically, we will address such questions as:

- Broadly speaking, will the climate changes anticipated have a greater impact on the utility’s natural assets or constructed assets?
- How is the overall balance of supply and demand likely to change under the CCDS?
- What types of natural assets (whether surface water, springs, or groundwater) are likely to face higher levels of risk under the CCDS? Are there specific geographic locations, for example, where the risks are largest?
- What types of constructed assets (whether intakes, treatment plants, reservoirs, or distribution pipes) are likely to face higher levels of risk under the CCDS? Are there specific geographic locations where the risks are largest?

Notably, the concept of climate change-driven scenario planning is distinct from the concept of emissions scenarios, which is discussed in greater detail in the text box on the following page.
How do the changes articulated translate into modified scores in the Asset Risk Matrix? Which assets, in other words, should receive increases to their scores in light of potential climate change hazards?

How do the changes articulated translate into revised vulnerability maps? Are there vulnerability hotspots, in other words, that should be expanded? Are there new hotspots that should be added?

To what extent can we also quantify the elevated risks identified in terms of decreased volume of raw water, decreased volume of treated water, number of unserved/underserved customers, or value of assets at risk?

To facilitate consensus building on these important questions, IUWASH facilitates a workshop with the water utility and its local government owner; presenting the preliminary findings and seeking input from a wide spectrum of staff within the PDAM and PEMDA.

Intergovernmental Panel on Climate Change (IPCC) Emission Scenarios.

One of the principle complexities associated with modeling climate change impacts is determining how the global climate will respond to existing greenhouse gas emissions levels. The level of complication is further exacerbated by the fact that future levels of greenhouse gas emissions may well vary from those of today. To help address this additional variable and provide context to climate change planning, the IPCC has developed a series of emissions scenarios. More specifically, as described in the IPCC Special Report on Emission Scenarios (2000), there are essentially four families (p. 5):

The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system.

The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities.

Fertility patterns across regions converge very slowly, which results in continuously increasing global population. Economic development is regionally oriented and per capita economic growth and technological change are more fragmented and slower than in other storylines.

The B1 storyline and scenario family describes a convergent world with the same global population that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives.

The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented toward environmental protection and social equity, it focuses on local and regional levels.
3.2.3. ADAPTATION PLANNING – RISK MANAGEMENT RESPONSE

According to the IPCC (2012) adaptation to climate change takes place among both human and natural systems. Specifically, adaptation in human systems is the “process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities.” In terms of natural systems, adaptation refers to “the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate” (p. 36). Thus, whether in the context of human or natural systems, adaptation is a process of adjustment, meaning that it is not a one-off action, but rather an iterative progression of proactive and reactive measures.

Climate change adaptation actions can take many different forms. Broadly speaking, these actions can be classified into the following categories (Cabot Venton, 2012):

- **Modification of Existing/Planned Activities.** One of the most straightforward types of adaptation responses is to alter activities or projects that already have a dedicated budget based on specific climate change considerations. Such adaptation measures may be considered the “low-hanging fruit” in that the additional costs required are marginal while the potential gains may be significant in terms of encouraging climate resiliency. One example would be the placement of a new water treatment plant that is already included in the utility’s capital plan; specifically, instead of constructing the plant 100 meters from a river, it is worth considering whether locating the plant could be located 250 meters from the river, thereby reducing the flood risk.

- **No/Low Regrets Options.** “No regrets”-adaptation options are those that deliver net benefits over the entire range of anticipated future climate and associated impacts (IPCC, 2012). In other words, no/low regrets adaptation options will deliver development gains whether or not the science behind climate projections is fully accurate. Encouraging water-use efficiency, for example, is one adaptation option that can benefit households, industry, utilities, and the environment as a whole regardless of how changes in temperature are ultimately manifested.

- **Soft Resilience Actions.** Similar to no regrets options, soft resilience measures generally consist of policy or ecosystem-based responses to climate change that are of lower cost. The rehabilitation of a degraded watershed through replanting represents an example of a soft-resilience adaptation action that can yield significant impact at a relatively low cost. Notably, “low cost” does not equate with “easy to implement.” Indeed, one of the greatest challenges often associated with soft resilience is that they tend to require a high degree of collective action, meaning that a broad group of stakeholders must agree on the action and support its implementation.

- **Hard Resilience Actions.** As the name implies, hard resilience actions tend to be infrastructure intensive and require a greater degree of due diligence upfront to ensure that they are appropriate. The construction of a dam, for example, would be considered as a hard resilience action if the dam is deemed necessary to control more volatile river flows as a result of climate change.

The process for identifying specific adaptation options is, in many ways, similar to the decision-making path for water utility investments more broadly in that it moves from a “long-list” of actions down to a “short-list” of actions. Further, the short-list of actions is then assigned a level of priority in terms of response to be implemented immediately and those that will be planned for the medium or longer term. The specific steps are discussed in greater detail below.

(a) Develop Long-List of Adaptation Options for Natural and Constructed Assets. The first step is to enumerate a “long-list” of potential adaptation options that can be taken to boost the resilience of the PDAM’s natural and constructed assets. IUWASH works with the PDAM to brainstorm a complete list of the broad range of potential actions that may be taken to address the risks identified during the first two phases. Table 2 at the top of the following page represents an example of the variety of actions that may be taken, including what actions are already included in the IWUASH scope.
of work and thus may be directly supported by the Project. Also, Annex C presents a more extensive list of adaptation measures organized according to hazard type.

(b) Develop a Short-List of Adaptation Options. Moving from an extensive list of adaptation options to a short list of feasible actions is one of the greatest challenges of developing a climate change adaptation strategy, especially in an environment of considerable uncertainty. Importantly, this uncertainty can still be mitigated through the adoption of the aforementioned no/low regrets options, as well as through the identification of a portfolio of responses. Similar to making financial investment decisions, the development of a portfolio options avoids putting “all your eggs in one basket,” leading to a more balanced and robust adaptation plan.

To assist PDAMs to identify their short-list or portfolio of adaptation options, IUWASH works collaboratively with the utility to conduct a multi-criteria analysis (MCA) of the available options. Simply stated, MCA provides a decision-making framework by combining both quantitative and qualitative criteria to assess and compare impacts (Cabot Ventron, 2012). Illustrative criteria might include cost, technical complexity, political acceptability, speed of implementation, and size of beneficiary group (impact). Criteria are then assigned a score (i.e. 1, 2, 3) or rating (i.e. high, medium, low) to facilitate the comparison of options. While somewhat subjective, a key advantage of MCA is that it generally allows decision-makers to quickly rule out a large percentage of the long-list and begin to hone in on a

<table>
<thead>
<tr>
<th>Adaptation Classifications</th>
<th>Specific Responses</th>
<th>Included in IUWASH SOW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Water Protection</td>
<td>Watershed Protection: Establishment of protected zones critical for water recharge or spring protection</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Aquifer recharge programs</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Farmer extension programs aimed at reducing soil erosion</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Improved waste collection and treatment</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Payment for Environmental Services</td>
<td>✓</td>
</tr>
<tr>
<td>Water Efficiency and Demand Management</td>
<td>Non-Revenue Water Reduction</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Water meter maintenance and replacement</td>
<td>✓</td>
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<tr>
<td></td>
<td>Efficient water pricing (i.e. increasing block tariffs)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Social marketing for consumer behavior change</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Consumer incentive programs (i.e. low-flow devices)</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Wastewater reuse for agriculture and industry</td>
<td>✓</td>
</tr>
<tr>
<td>Infrastructure Options</td>
<td>Enhance/expand storage capacity through construction of new reservoirs</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Diversify water resources through construction of deep wells, new surface water intakes, and inter-basin transfers</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Check dams to slow runoff and facilitate aquifer recharge</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Increase access to improved urban sanitation systems to reduce pollution of upstream water sources and local groundwater</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Expanded wastewater treatment for water reuse in agriculture and industry</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Expand/upgrade urban drainage systems</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Construction of berms, dikes, or sea walls</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Relocation / strengthening water infrastructure subject to flooding</td>
<td>✓</td>
</tr>
<tr>
<td>Information Management</td>
<td>Water Allocation Decision-Support Systems</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Hydrological / Meteorological Monitoring Stations</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Computerized Billing and Accounting</td>
<td>✓</td>
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</table>
viable portfolio of action items. The process of multiple criteria analysis is described more fully in the following section of the report.

It is critical to note that the multiple criteria analysis—indeed, the process of identifying adaptation options as a whole—must be approached in a participatory and transparent manner. In this regard, IUWASH facilitates a series of discussion with the utility and local government, culminating in a stakeholder workshop to walk through the MCA and develop a consensus of the most viable portfolio of adaptation actions.

**3.2.4. IMPLEMENTATION, INTEGRATION, AND LEARNING**

The final phase of the Vulnerability Assessment and Adaptation Planning Framework consists of three specific steps: implementation, integration, and learning.

**(a) Implementation.** Based on the portfolio of adaptation options identified and prioritized under the third phase, the PDAM will then begin to implement the near-term actions. Notably, “implementation” may take several forms. In the case of adaptation options that are entirely under the authority of the PDAM—such as a non-revenue water program or improvements to decision-support systems—these can essentially roll-out at the field level immediately given that minimal external support or consultation is required. For other proposed actions with a broader set of institutional stakeholders, the first phases of “implementation” may actually consist of a broader set of stakeholder consultation in order to build the support needed to move forward. In the case of ecosystem adaptation responses, for example, local communities within the targeted ecosystems will need to be informed and engaged concerning the need for and approach to improved ecosystems management. Finally, for medium to long-term hard resilience adaptation options included in the portfolio, “implementation” may take the form of expending resources to undertake a more detailed engineering study or financial feasibility analysis.

Implementation is, of course, always contingent upon funding. While the modification of planned activities to be climate resilient is likely to impose minimal additional costs on the utility or local government, there are certainly other adaptation options such as the addition of greater storage capacity that require substantive investment. While some PDAMs may have the liquidity to pay for such investments directly from their cash flow, others may require external funding. In addition to equity injections from a local government owner, other sources of funding include the following:

- **Central Government.** The GOI has a number of programs already in place that may be tapped for funding specific adaptation programs. The Indonesian Government has budgeted IDR7.4 trillion through 2014, for example, to help local governments and PDAMs secure and protect the raw water supplies needed to meet current and future demand.
- **International Donors.** Many bilateral and international donors or increasingly channeling resources into climate resilient development. In Indonesia, the World Bank, Asian Development Bank, GIZ, and AusAID are all active in the climate change sector.
- **Private Sector.** Whether as corporate social responsibility (CSR) or efforts to promote corporate sustainability, the private sector also increasingly recognizes the need to “give back” and, in doing so, protect the very environment that allows them to operate. Coca-Cola Indonesia, for example, is supporting the instillation of artificial recharge technologies in the upper watersheds of the greater Medan metropolitan area, thereby boosting the resilience of the basin in which it operates.

The multi-disciplinary nature of climate change adaptation means that many of IUWASH's experts have a role in implementation. IUWASH hydrology specialists, for example, can assist water utilities in determining the
The best approach to protecting valuable natural assets such as fresh water springs. Our municipal finance experts can support the preparation of financial feasibility studies to obtain external financing from the central government. Finally, IUWASH engineers can review detailed engineering designs to help ensure that potential climate change vulnerability are taken into consideration prior to the commencement of construction.

(b) Integration. In conjunction with the commencement of the implementation of adaptation options it is also important that the overall adaptation strategy be fully integrated into the utility's broader development planning. Specifically, the results of the vulnerability assessment and adaptation planning will be integrated into the PDAM's existing corporate plan. Indeed, an important part of the longer term vision for bolstering PDAM resiliency is that climate change concerns be incorporated into the five-year corporate planning process such that all future planning documents contain a specific section or specific references to potential climate change impacts, including updates on the latest scientific projections based on current climatic trends.

(c) Learning (Monitoring and Evaluation). As noted in the principles at the start of this chapter, climate change vulnerability assessment and adaptation planning is, ultimately, an iterative process. Monitoring and evaluation is, then, a critical aspect of ensuring that the next iteration of adaptation planning builds upon past successes and missteps. Simply put, the final step of the IUWASH VAAP Framework is about learning. While much research has been carried out in recent years concerning the likely impacts of anthropogenic climate change and how to best respond to it, the reality is that there is still much that we do not know. In other words, there is still a lot to learn. As the IPCC (2012) notes, “The dynamic notion of adaptation calls for learning as an iterative process in order to build resilience and enhance adaptive capacity now, rather than targeting adaptation in the distant future” (p. 468).

An important part of the longer term vision for bolstering PDAM resilience is that climate change concerns be incorporated into the five-year corporate planning process.

Figure 5 portrays the cyclical nature of the IUWASH VAAP Framework. As depicted in the left-hand side of the figure, the final phase of implementation, integration, and M&E eventually gives way to a reassessment of the baseline scenario and the associated climate change risks. In this way, the VAAP Framework can be readily integrated into the PDAM's broader planning processes, which occur on a five year cycle.
SUPPORTING TOOLS FOR VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING
Chapter 4 explores a number of key tools that IUWASH will utilize to support the climate change vulnerability assessment and adaptation planning process described in the previous chapter. Notably, these tools are meant to contribute to the overall process of assessment and planning, as opposed to suppressing discussion by providing unequivocal “answers.” Above all, it is critical that stakeholders understand how and why these tools are utilized, thereby ensuring transparency and sustainability throughout the implementation of the VAAP Framework.

### 4.1. PDAM ASSET RISK MATRIX

Conducting a vulnerability assessment for a water utility can represent an intimidating task given the many forms of existing risk. In order to organize and simplify this process, a systematic methodology is necessary to help quantify risk and focus the analysis on those assets that appear to be the most vulnerable. Probabilistic risk analysis offers one approach to quantifying risk for a set of assets. As noted by the IPCC (2012), when implemented under the auspices of a broader risk governance framework, probabilistic risk analysis (PRA) represents a powerful means to “help allocate and evaluate efforts to manage risk.” Simply stated, PRA is defined as:

**Risk = Probability x Consequence**

Fundamentally, this equation considers the likelihood that a given hazard will occur and multiplies it by the magnitude of the expected physical or environmental damages in order to assess to overall level of risk. In this regard, an asset faces a high risk level if there is both a high probability of hazard occurrence as well as a high magnitude of anticipated damages. Figure 6 below visually portrays the relationship between probability and consequence, with the illustrative water treatment plant subject to both a “likely” probability and “high” consequences, meaning that it faces the most extreme level of risk.

```
Consequence

High          | WTP | Reservoir
Low           |     | Spring

Probability

Unlikely      | Low: Some action (education, training) may be required
Likely        | Moderate: Some controls required to reduce risk

Negligible: No action required
High: High priority control measures required
Extreme: Immediate control measures required
```

Figure 6: PDAM Asset Risk Matrix
In many ways, the concepts of probability and consequence are directly tied to those of exposure and vulnerability. An asset with a low level of exposure, for example, will have a low likelihood of experiencing a hazard in the first place; similarly, a highly vulnerable asset is likely to face more extreme consequences than one with low vulnerability.

Building on the concept of probabilistic risk analysis, IUWASH developed the PDAM Asset Risk Matrix, a semi-quantitative risk assessment tool to assist water utilities in methodically evaluating the level of risk faced by their natural and constructed assets. More specifically, the Asset Risk Matrix (ARM) provides a means to calculate a simple risk score for the specific assets of each water supply subsystem, where a “subsystem” is defined as the series of connected assets that take water from the natural environment, transport it, treat it, and store it. Figure 7 below represents a single water supply subsystem. In many cases, a utility possesses multiple water supply subsystems, often times delivering water to different geographic areas within its service area. Notably, the natural asset—or the source of raw water—may take several forms, including a river, fresh water spring, or aquifer. Also, depending on the nature of the raw water source and the distance to the end user, some of the constructed assets (such as a treatment plant or storage facility) may not be required. The scoring and implementation methodology for the Asset Risk Matrix are described in greater detail in the following sub-sections.

4.1.1. SCORING METHODOLOGY

When evaluating the level of risk for each water supply subsystem, IUWASH works collaboratively with the PDAM to assign levels of probability and consequence to each asset throughout the subsystem. Concerning the assignment of probability to specific hazards, the analysis for the baseline scenario will utilize historical data to assess the frequency of four different hazard types: floods, drought (water stress), landslides, and sea level rise. The probability of a flood event occurring, for example, can be based on long-term rainfall or flow data in streams; generally speaking, such events are expressed as 2-year

---

**Figure 7: Elements of a Water Supply Subsystem**

- **NATURAL ASSETS**
  - Watershed
  - Surface Water and Groundwater

- **CONSTRUCTED ASSETS**
  - Intake
  - Transmission Pipeline
  - Water Treatment Facilities
  - Storage & Distribution
(1 in 2), 10-year (1 in 10), or 100-year (1 in 100) floods. After consulting available data, each hazard type will then be categorized according to the following table:

### Table 3: Scoring Guidelines for Probability of Occurrence

<table>
<thead>
<tr>
<th>SCORE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Extremely high probability of occurrence based on historical records and climate change projections. Hazard is virtually certain to occur within stated timeframe.</td>
</tr>
<tr>
<td>4</td>
<td>High probability that stated hazard will occur within timeframe. Observed data and projections show general consensus towards increased occurrence.</td>
</tr>
<tr>
<td>3</td>
<td>Medium probability that stated hazard will occur. Risk is “less likely.”</td>
</tr>
<tr>
<td>2</td>
<td>Low probability that stated hazard will occur. Risk is possible but unlikely.</td>
</tr>
<tr>
<td>1</td>
<td>Very low probability that stated hazard type will occur. Risk is a virtually nonexistent to an extremely remote possibility.</td>
</tr>
</tbody>
</table>

### Table 4: Scoring Guidelines for Magnitude of Impact

<table>
<thead>
<tr>
<th>SCORE</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Long-term impact (years) with complete loss of assets and very high monetary losses.</td>
</tr>
<tr>
<td>4</td>
<td>Significant seasonal (months) or episodic impacts with significant asset damages or monetary losses.</td>
</tr>
<tr>
<td>3</td>
<td>Short term impact (weeks) with moderate but asset damages.</td>
</tr>
<tr>
<td>2</td>
<td>Very short term impact on service levels (days) with easily repairable/recoverable damage levels.</td>
</tr>
<tr>
<td>1</td>
<td>Impact to service levels nonexistent or imperceptible to customer. Hardly any asset damages.</td>
</tr>
</tbody>
</table>

The potential consequences (or magnitude of impact) of flooding, landslides, sea level rise, and drought due to climate change are outlined on the right side of the bow-tie diagram in Section 3.2.1. Such consequences can be analyzed in terms of raw water availability (supply needs), monetary costs to the PDAM, and impacts on customers. While consequences can, like hazard probability, be evaluated qualitatively, semi-quantitatively, or quantitatively, the PDAM ARM adopts a qualitative approach given the limited data available in many of the locations where IUWASH is working. Table 4 below presents a scoring matrix based on such an approach, with high scores based on high physical damage and low scores related to little or no damage. As information on historical damage is determined by events, a more quantitative approach can be developed.

Finally, once scores are developed for each subsystem, they may also be adjusted (i.e. weighted) based on the percentage of people served, the poverty level, or other factors. For instance, if a water treatment plant serves half the population within a municipality, the consequences of a hazard affecting these types of facilities would be higher than for a spring or well serving only 10% of the population.

### 4.1.2 PDAM ARM IMPLEMENTATION

As noted in Chapter 3, the Asset Risk Matrix is used at two points in the implementation of the VAAP Framework, namely, in the vulnerability assessment of the baseline scenario (Phase 1) and again in the assessment of a climate change driven scenario(s). Under the auspices of the baseline scenario, the ARM will be used to gauge the risks to utility assets under the present-day climate. In other words, based on historical data and local stakeholder inputs, what are the probabilities and consequences of known hazards assuming a stationary climate? Importantly, this is not to say that the risks identified under the baseline scenario are not in part driven by initial changes to the climate overall the past few decades, but simply that no additional changes are anticipated going forward.

Under Phase 2—the development of the climate change driven scenario—the Asset Risk Matrix will then be adjusted based upon the potential impacts of climate change. Returning to the elements of the water supply
subsystem set forth under Figure 6 above, potential types of increased risk include the following:

- **Raw Water Sources:** Increasingly erratic precipitation is likely to have significant effects on natural assets of water utilities, leading to less reliable sources of raw water. Depending on the availability of data, analytical models may be used to define ‘what if’ scenarios and bring greater clarity on how raw water sources may be impacted. These may consist of simple water balance models for a particular watershed or more sophisticated groundwater, which can be used to determine the potential for saltwater intrusion and surface water flow models. Input to these models would be driven by site-specific climate change models and calibrated by historical data.

- **Transmission Pipelines:** The potential for landslides in steep areas and corrosion of pipes in low-lying areas near the sea due to saltwater intrusion pose the biggest threats to pipelines. Using GIS or other mapping techniques, these areas should be identified and the hazards mapped.

- **Treatment:** The biggest threat to treatment facilities is likely to be the increased potential for flooding. Using models such as HEC-RAS or historical data, hazard areas can be mapped and mitigation measures can be planned. In addition, sediment transport models can be developed to determine what steps need to be taken to protect freshwater reservoirs, based on land use and climatic changes.

- **Storage Facilities:** Similar to treatment facilities, the most significant threat to PDAM storage facilities (reservoirs) is likely to be flooding if such facilities are located in close proximity to surface water sources such as rivers. Landslides may also be a tangential risk to reservoirs, but this is considered minimal given that most reservoirs are not built on or near steep terrain.

Based on the extent to which climate change exacerbates and/or introduces new hazards, then, we may see shifts in the Asset Risk Matrix towards overall higher levels of risk. In Figure 8 below, for example, the construction of the climate change-driven scenario has intensified the risk level for the water treatment plant and natural spring, while no additional threats are perceived for the reservoir facility.
Throughout implementation it is, of course, important to bear in mind that the PDAM Asset Risk Matrix is a rapid assessment tool based on qualitative measures. As such, it is not meant to offer detailed, prescriptive answers, but to inform the vulnerability assessment process, providing a systematic approach to evaluating the different elements of risk.

### 4.2. GEOSPATIAL ANALYSIS

The risks posed by climate change are inherently spatial, closely tied to the geographic characteristics of specific locations including land use, proximity to inland bodies of water and the coast, topography (slope), and population density. Geographic information systems (GIS) offers a powerful tool to analyze and visualize how climate change may heighten or introduce new risks to a PDAM’s natural and constructed assets.

Toward this end, IUWASH works with the PDAM and local government to develop the following types of spatial analyses under the baselines scenario:

- **Watershed Land-Use Patterns.** The way in which land is being utilized across the watershed has a significant impact on the sustainability of raw water sources. Thus, when developing the baseline scenario it is important to clearly delineate land use patterns, understand how they currently impact raw water sources, and how climate change may exacerbate existing land-use challenges (such as decreasing groundwater infiltration and increasing run-off). An illustrative map from Medan is shown in Figure 9 and 10, with the blue squares indicative of the utility’s raw water intakes. Where data is available, we will also include time series maps to show how land use has changed in recent years.

- **Historical Flood Patterns.** Under the baseline scenario we can use historical flood data to highlight flood prone areas in the past. This is particularly important in coastal areas, where sea level is of particular concern (see Figure 10). The map of historical flood events can also be integrated with maps of flood control infrastructure to highlight existing adaptive capacity (or the lack there-of).

- **Geology/Hydrogeology.** Mapping the conditions of the underlying rock and aquifer structures helps to demonstrate how different areas—including different water sources—are connected hydrologically. Notably, maintaining the health of aquifers is expected to become only more important as the climate changes given their potential to naturally store large volumes of water even as surface water sources periodically run dry.

- **Landslide Risk.** Using topographical data, we can map landslide risk based on a combination of slope and landcover characteristics. Also including PDAM intakes in the same map, we can quickly see which sources are vulnerable to being cut off due to landslides.

Depending on the availability of data, it may also be beneficial to overlay the above maps with socioeconomic information, including household poverty data. Doing so allows the PDAM to also take into consideration how consequences such as a disabled treatment plant may impact its customers, particularly those that are more vulnerable to water shortages. Similarly, we can also overlay multiple hazard maps—including flood risk, land use, landslide risk, and poverty levels—to identify “vulnerability hotspots” where two or more risks overlap.

**Geospatial analysis represents an important tool for identifying vulnerability hotspots, allowing us to overlay hazard maps and delineate locations where multiple risk factors converge.**
In addition to developing spatial analyses for the baseline scenario, IUWASH also works with the PDAM to consider how the locations and severity levels of certain risks may change under a climate change-driven scenario (Phase 3). In coastal areas, for example, we can visually map how changes in sea level may alter coastal inundation and salt water intrusion scenarios over the coming 30 to 60 years, for example. Further, using such a scenario, we can then consider how the aforementioned vulnerability hotspots may shift or expand over time. We can also easily map boundaries of upstream catchment areas (rivers, springs) and identify which local government is responsible for maintaining / improving qualify of the catchment as well as identify most suitable areas for the introduction of infiltration technologies.

Finally, in addition to being an analytical tool, geospatial analysis is also a communications tool as well. More specifically, GIS tools provide a powerful means to visually display information concerning the vulnerabilities of a PDAM’s natural and physical assets. Building on the above case of coastal flood mapping, visually showing decision-makers how ocean inundation is likely to creep further and further inland in the coming years—eventually affecting the viability of constructed assets such as water treatment plants, for example—can be a very effective means for communicating the importance of climate change adaptation actions.
4.3. GENERAL CIRCULATION MODELS

As noted under Section 3.2.2, General Circulation Models (GCMs)—also known as Global Climate Models (by the same acronym)—represent an important tool for constructing climate change-driven scenarios. Simply stated, GCMs are computerized, mathematically-driven projections of how the global climate is likely to react to “climate forcings” such as increased greenhouse gas emissions. The IPCC’s Fourth Assessment Report (2007) notes that, “Climate models are based on well-established physical principles and have been demonstrated to reproduce observed features of recent climate and past climate changes” (p. 591). The report goes on to conclude that, “There is considerable confidence that Atmosphere-Ocean General Circulation Models (AOGCMs) provide credible quantitative estimates of future climate change, particularly at continental and larger scales” (p. 591).

Notably, GCM’s have several important limitations. First, as the IPCC implies, the capacity of GCMs to accurately predict fluctuations in temperature and precipitation decreases at the regional and local level, as they do not take into account local characteristics such as proximity to bodies of water and other topographical features that significantly influence localized weather patterns. This challenge can be overcome through the use of “downscaling” techniques to generate regional climate models (RCMs), but such techniques are relatively new and have not been widely implemented in many places around the world, including Indonesia.

Second, climate feedback mechanisms—such as increased water vapor levels, cloud cover, and ocean circulation—remain difficult to predict in climate models and could potentially alter future climate in powerful ways.

Finally, by necessity, climate models are constructed based on certain assumptions concerning future GHG emissions levels. As noted in the text box under Section 3.2.2, emissions levels depend on economic development trends, population growth, the use of clean energy sources, and a host of other factors. Thus, uncertainty concerning future emissions levels also translates into uncertainty in climate change modeling, making it especially important to clarify the emission scenario used in each analysis.

Sources of Climate Data.

Recognizing that it is beyond the scope of IUWASH to fund in-depth climate change modeling, the Project will rely on a number of readily available, web-based climate change projection tools.

- **World Bank Climate Change Knowledge Portal.** The World Bank has a dedicated site for development practitioners and policy-makers with a wealth of climate change data, including historical data and climate projections. The projections are derived from 15 of the 23 available global circulation models (GCMs) used by the IPCC in the 4th Assessment Report and can be run under the SRES-A2 or SRES-B1 scenario. In terms of time periods, the projection periods begin in 2020 and continue to 2100 in 20-year blocks. (http://sdwebx.worldbank.org/climateportal/index.cfm)

- **Climate 1-Stop.Org.** The Climate 1-Stop Web Portal—which was developed by a group of donors, NGOs, and government organizations—provides a suite of information on climate change issues, including worldwide climate projections. More specifically, the portal provides outputs of three of the models used in the IPCC’s 4th Assessment Report: the National Center for Atmospheric Research Community Climate System Model (NCAR CCSM); the European Centre/Hamburg Model (ECHAM); and the Geophysical Fluid Dynamics Laboratory Coupled Model (GFDL-CM21). According to the website, these models were chosen because they represent the highest, middle, and lowest projections for changes in the climate variables. Notably, all outputs are based on the SRES A1B scenario, with the available time periods being 2030 to 2040, and 2041 to 2050. (http://arcserver4.iagt.org/climate1stop/Default.aspx?mode=modeDataVisualization)

- **SERVIR Earth Observation System.** Developed under a partnership between USAID and NASA, the SERVIR Program provides a web-based geospatial platform for analyzing and sharing different types of climate and natural resource data. The SERVIR Program (SERVIR is a Spanish acronym for “regional visualization and monitoring system”) currently has regional centers in Central America, East Africa, and the Hindu-Kush regions, and is looking to expand its network in the near future into Asia. The interactive web-mapping function displays data for natural resources, demographics, and climate.
Despite these constraints, GCMs still represent an important source of climate information when constructing “what-if” scenarios, particularly when coupled with other sources of information such as literature reviews and expert interviews. Whenever using GCMs, there are several key questions to answer:

- **What time period will be used for the projections?** When running a model, the user must always specify a time period for the climate projections. For example, many models are able to provide projections through the end of the century. Given IUWASH’s purposes, however, the Project generally uses more “near term” projections ranging from 2020 to 2050. Notably, the baseline data for most GCMs is from the period 1960 to 2000.

- **What SRES Scenario will be used?** The Government of Indonesia utilizes the SRES-A2 and SRES-B1 given that, from the GOI’s perspective, these scenarios best reflect current understanding and knowledge about underlying uncertainties in emissions (Ministry of Environment, 2010). Where possible, then, IUWASH utilizes SRES-A2 to inform the development of climate change scenarios. Should neither of these scenarios be available from a given source, we will then utilize the A1B scenario family, which approximates “business-as-usual” emissions projections.

- **Which models and sources will be used?** The IPCC’s fourth assessment report used more than 20 GCMs to conduct its analyses, and thus there are many different models from which to choose. IUWASH will rely, however, on web-based GCM platforms such as the World Bank’s Climate Change Portal, the Climate1Stop web platform, and the USAID-NASA sponsored SERVIR climate tool. These platforms—and the specific models they employ—are summarized in the text box above.

It terms of utilizing GCM’s to develop “what-if” scenarios, model outputs can be particularly useful in stimulating discussion among stakeholders concerning how climate change may impact the local environment in the coming decades. Once again, given the limitations of GCMs to accurately predict localized climate change impacts, they are best interpreted as simply one potential profile of what may happen as the consequences of climate variability unfold. Nonetheless, when presented graphically in contrast to current climate conditions, they offer a powerful discussion piece to kick-off debate among water utility staff, local government officials, and other key stakeholders. Figure 11 at right, for example, compares average precipitation for the City of Medan with predicted precipitation levels generated by the

![Figure 11: Medan Monthly Precipitation vs. A1B 2031-2040 Prediction](image)
Climate Change Stop web portal (SRES A1B). Overall, the model suggests decreased levels of precipitation, with the exception of May and June. Recognizing the limitations inherent in any modeling exercise, such graphics can nonetheless help policy-makers to visualize and plan for an increasingly variable climate.

4.4. MULTI-CRITERIA ANALYSIS AND COST-BENEFIT ANALYSIS

Moving from a long list of adaptation options to a condensed portfolio of prioritized adaptation options—Phase 3 of the VAAP Framework—can be very challenging in an environment of high uncertainty. Multi-criteria analysis and cost benefit analysis represent two decision-making tools that can help policy-makers make difficult decisions as they seek to allocate scarce resources.

4.4.1. MULTI-CRITERIA ANALYSIS

Multi-criteria Analysis (MCA) provides a decision-making framework in which stakeholders identify and assess multiple impacts from a range of policy or adaption options (Cabot Venton, 2012). Semi-quantitative in nature, MCA provides a logical starting-point in the process to select adaptation options by helping stakeholders to clearly articulate what qualities they are looking for and which potential adaption options best reflect those qualities. MCA is appropriate in situations where the potential adaptation options and desired criteria cannot necessarily be expressed in a single unit of measurement (such as monetary value), thus making it more difficult to compare and contrast impacts. MCA is also especially suitable for more “rapid assessment” efforts, where policy-makers are first interested in simply narrowing down a long list of options before engaging in a more rigorous and detailed analysis of a discrete set of options.

Broadly speaking, multi-criteria analysis includes the following key steps:

1. **Identify Long-List of Adaptation Options.** As noted under Phase 3 of the IUWASH VAAP Framework, the first fundamental step is the identification of the “long-list” of adaptation options under consideration. Table 2 under Section 3.2.3 above provided an illustrative list of potential adaptation options for PDAMs, with a more extensive listing of options also included under Annex C. These lists represent starting points only, however, and the PDAM and local government may well have other options that should be included as well.

2. **Identify Evaluation Criteria.** The second step is for the water utility and local government to articulate how they would like to evaluate the various adaptation options in terms of which specific criteria will be used in the analysis. Figure 12 below provides examples of criteria that have been used in the past by three

![Figure 12: Illustrative MCA Evaluation Criteria](Source: Cabot Venton, 2012)
different donor agencies. Notably, it is important to define what is meant by each criterion, especially when very broad evaluation criteria such as “effectiveness” are selected. That said, precision and robustness (in terms of the number of criteria utilized) also need to be balanced with the need to keep the process as simple and transparent as possible.

3. Develop Scoring and Weighting Methodology. Generally speaking, MCA scoring uses a relatively simple ordinal (1, 2, 3, etc.) or categorical (low, medium, high) system for assigning scores. Further, if specific criteria are deemed to be more important than others, then it is also possible to assign a weighting to reflect this preference.

4. Assign and Aggregate Scores. Once the scoring approach is agreed upon, stakeholders can then walk through each adaptation option and assign a specific score, with each the individual scores of each criteria ultimately summing to an overall score for each respective adaptation option.

5. Rank Adaptation Options and Identify Top Tier. Using the final scores, the "long-list" of adaptation options can then be ranked to facilitate the selection process. Importantly, just because an adaptation option such as construction of new reservoir appears at the top of the ranking, this does not necessarily imply that it should be selected. Rather, stakeholders should collectively review and discuss the results and determine what modifications need to be made. For example, assuming that the PDAM desires to move from a long-list of 50 adaption options to a top tier of 10 actions, the PDAM should not automatically select the 10 highest scoring actions. Indeed, there may be other considerations that emerge from the discussion process that cause some lower-ranked options to be included in the final portfolio, such as the need to include a balance of both “hard” adaption options (e.g. construction of infrastructure) and “soft” adaption options (e.g. ecosystem-based or policy actions).

By way of an example of how multi-criteria analysis may be used to consider adaption actions, please see Annex D which presents a table used by USAID and DAI to evaluate a suite of climate change responses in the Philippines.

Two additional points should be kept in mind when undertaking MCA. First, MCA is fundamentally meant to be a collaborative effort; it is not intended to be a “black box” decision-making framework implemented by a consulting team. As such, MCA is best carried out in a workshop setting, with stakeholders from the PDAM and local government determining the nature of the long-list, the type of evaluation criteria, the scoring methodology, and the final selection of the top-tier response actions. In this regard, a common format is to have the larger group break into small teams to score and rank adaptation options. The results from each team can then be shared in a plenary session, and compared across the larger group as a whole, noting the reasons that respective adaptation responses may have been ranked lower or higher.

Finally, on a related note, MCA is as much about facilitating a systematic, participatory evaluation process as it is about scoring and ranking adaptation options. Indeed, one of the greatest values associated with MCA is the manner in which, by necessity, it brings stakeholders together around the table to share viewpoints and move towards consensus.

4.4.2. COST-BENEFIT ANALYSIS

Cost-benefit analysis (CBA) is a second decision-making tool that attempts to account for the economic costs and benefits of certain policy options. While it is beyond the scope of this inception report to provide a detailed discussion on CBA methodology, broadly speaking, it consists of calculating the net present value of the stream of expected monetary costs and benefits associated with any one adaption option. The Economics of Climate Adaption Working Group (2009) characterizes costs and benefits as follows:

- Economic costs of an adaption measure may include capital expenditures (such as infrastructure construction costs) and operating expenditures (such as labor costs, supplies, maintenance costs, depreciation expenses, and the like). Notably, the economic costs of the measure should also be reduced by any anticipated operating expenditure savings. While some might classify projected savings as “benefits,” it is important for them to be classified in conjunction with operating costs for analytical purposes. In this regard, it is possible for a measure to be “cost negative.”
- **Economic benefits** of an adaptation measure may be defined as “loss averted and any additional revenue streams created by a measure (if applicable)” (p. 133). Importantly, the costs of the loss averted may be derived from estimated reductions in physical damages by either reducing the severity of an event (such as a flood) or increasing the resilience of the asset as well as reductions in the value of exposed assets in the first place (i.e. the relocation of a physical asset).

Conducting a CBA generally requires the development of a financial model to account for the multiple revenue flows and fiscal savings associated with the implementation of the proposed adaptation measure. Given the amount of time associated with such an effort, CBA will generally be limited to the prioritization of adaptation measures identified under the MCA process. In other words, it makes little sense to use CBA to analyze 50 different adaptation options when many of them will likely be eliminated regardless based upon other criteria. Thus, IUWASH assists the PDAM in carrying out a cost-benefit analysis if it is deemed necessary to, for example, chose between two or three highly ranked adaptation options.
IMPLEMENTING THE WATER SUPPLY VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING FRAMEWORK
The IUWASH Water Supply Vulnerability Assessment and Adaptation Planning Framework represents a collaborative and practical approach to assisting PDAMs and their local government owners to better plan for increased climate variability. Simply stated, the framework: (1) examines the risks to a PDAM's natural and constructed assets under the existing climate; (2) considers how those risks may shift and/or intensify under a climate change-driven scenario; (3) seeks to develop a balanced portfolio of cost-effective adaptation options; and (4) facilitates learning throughout the implementation process to continually improve upon and adjust adaptation measures as environmental conditions change.

5.1. SITE SELECTION

In accordance with the Project's scope of work, IUWASH implements the VAAP Framework in a minimum of 20 PDAMs, with adaptation action plans agreed upon and under initial implementation by the close of the Project. In the selection of these sites, IUWASH considers the following key criteria:

- **Severity of Existing Risks.** When conducting initial site assessments, IUWASH focused on those areas already facing severe risks to the sustainable provision of clean water. Particular emphasis is given to PDAMs experiencing raw water shortages under existing climatic conditions.
- **Motivation of the PDAM.** The commitment and motivation of the PDAM to proactively addressing climate change risks represents a major factor in their ability to adapt to climate risks.
- **Local Government Support.** As noted in the introduction, IUWASH's work is grounded in improved governance in the water sector, and thus the Project only operates in municipalities where there is tangible local government support. Specifically, areas where local governments are working to collaboratively manage scarce water resources across political jurisdictions are preferred.
- **Regional Balance.** IUWASH strives to maintain a balance of 3 to 5 PDAMs addressing climate change risks in each region.

While the specific locations where IUWASH implements vulnerability assessments and adaptation planning was still evolving at the time of the publication of this report, based upon the needs assessment conducted in the first year of the Project, potential PDAMs include the following table:

<table>
<thead>
<tr>
<th>Region</th>
<th>Location</th>
<th>Type of Water Source</th>
<th>Current Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Spring</td>
<td>River</td>
</tr>
<tr>
<td>North Sumatra</td>
<td>Medan</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Pematang Siantar</td>
<td>X</td>
<td></td>
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<tr>
<td></td>
<td>Sibolga</td>
<td></td>
<td></td>
</tr>
<tr>
<td>West Java/Banten</td>
<td>Serang</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Bandung (district)</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Bogor (city)</td>
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<td></td>
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<tr>
<td></td>
<td>Karawang</td>
<td>X</td>
<td></td>
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<tr>
<td>Central Java</td>
<td>Kudus</td>
<td>X</td>
<td></td>
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<tr>
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<td>Semarang</td>
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<td>East Java</td>
<td>Mojokerto</td>
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<td>Batu</td>
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<td></td>
</tr>
<tr>
<td>South Sulawesi &amp; Eastern Indonesia</td>
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<td>Enrekang</td>
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<tr>
<td></td>
<td>Pinrang</td>
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</table>
5.2. IMPLEMENTATION ACTIONS

In order to facilitate the implementation of the VAAP Framework by IUWASH technical and regional teams, it is necessary to translate the combination of concepts and tools presented in the Framework into concrete implementation actions. Table 6 below, then, describes the specific implementation actions that the IUWASH teams undertake in conjunction with our PDAM, local government, and university partners.

The final column in Table 6 maps the four phases of the VAAP Framework to the specific implementing actions presented. Notably, there is a degree of overlap among the actions when compared to the phases of the Framework given that many of the collaborative events with stakeholders necessarily address both baseline risks as well as climate change-driven risks.

In partnership with the respective PDAM, IUWASH ultimately produces a stand-alone Climate Change Vulnerability Assessment and Adaptation Plan report for each utility that summarizes the results of the

| Table 6: Implementation Actions for Vulnerability Assessment and Adaptation Planning |
|-----------------------------------------------|-----------------------------------------------|-----------------------------------------------|
| Actions                                      | Outputs                                      | VAAP Framework Phase |
| 1. Initial site assessment                    | • Engage PDAM and Local Government (LG) to determine need and commitment for CC VAAP | • Site Selected • Kick-off Meeting Held |
| 2. Climate Change Vulnerability Assessment (CCVA) Baseline Study | • Prepare Scope of Work for third party • Tender Fixed Price Contract • Implement CCVA Baseline Study • Review/approve Baseline Study Report | • Stakeholder Consultations • Approved CCVA Baseline Report |
| 3. Asset Risk Matrix (ARM) Analysis           | • Prepare Baseline Asset Risk Matrix for presentation/diagnosis with PDAM | • Baseline Asset Risk Matrix Prepared |
| 4. Workshop with PDAM Operators and LG (SKPD) | • Review results of CCVA Baseline with PDAM and LG • Present ARM Baseline • Collaboratively consider how climate change may alter ARM baseline • Discuss long-list of adaptation options | • Revised ARM Baseline • Climate Change Driven ARM • Long-list of adaptation options |
| 5. Synthesize Workshop Results and Prepare VAAP Draft Report | • Record results of workshop and finalize ARM results • Draft Vulnerability Assessment & Adaptation Plan (VAAP) Report • Prepare Draft VAAP Presentation | • Draft VAAP Report • Draft VAAP Presentation |
| 6. Decision-Makers Workshop                  | • Present overall results of VA • Present adaptation long-list • Collaboratively discuss short-list using multicriteria analysis | • Prioritized adaptation options |
| 7. Finalize CC VAAP Report                    | • Integrate results of decision-makers workshop into VAAP report, including short-list of adaptation options | • Final CC VAAP Report for PDAM |
| 8. Integration of Results into PDAM Business Plan | • Work with PDAM managers to integrate results into their Business Plan | • Agreement to integrate results into business plan |
| 9. Support Implementation of Adaptation Measures | • TA to support PDAM to implement measures under its control • Advocate for new policies where needed for LG • Identify/leverage new financing • Monitoring/Evaluation of measures and adjustment as needed | • At least one adaptation measure under implementation |
vulnerability assessment and adaptation planning process. A draft outline for these “utility reports” is attached as Annex E. As noted previously, IUWASH also seeks to have the results integrated or “mainstreamed” into the PDAM’s corporate planning process.

Finally, just as climate change vulnerability assessment and adaptation planning is best conducted on an iterative basis, so too will IUWASH continue to revisit, modify, and improve the water supply VAAP Framework as more experience is gained over the course of IUWASH implementation.
REFERENCES


ADB. 2009. ‘Climate Change and Its Impact: A Review of Existing Studies’ (Chapter 3), in The Economics of Climate Change in Southeast Asia: A Regional Review Asian Development Bank, Manila.


Intergovernmental Panel on Climate Change (IPCC). 2012. Managing the Effects of Extreme Events and Disasters to Advance Climate Change Adaptation.


Susandi, A. 2007. ‘Perubahan iklim Indonesia dan implikasinya.’ Program Studi Meteorologi - ITB Bandung


UNFCCC. 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries.


ANNEXES

ANNEX A:
ANNOTATED BIBLIOGRAPHY

Anshory Yusuf, A. & Francisco, H. 2009. Climate Change Vulnerability Mapping for Southeast Asia. Economy and Environment Program for Southeast Asia (EEPSEA). This document provides very general, broad conclusions on the vulnerability of different countries and regions to climate change. A lack of time, resources and available data constrained the specificity and usefulness of the models/conclusions. Only a limited number of vulnerability assessments had been completed on the region previously. Accurate weighting of some indicators was not done (instead simply shared evenly) due to lack of data. Other weighting was done either by expert polling or through an executive decision. Policy and Institutions’ could not be used as an indicator of adaptive capacity because insufficient data were present. West and South Sumatra and West Java are shown as most vulnerable to climate change in Indonesia. Although there is relatively high adaptive capacity in Jakarta and Bangkok, they are still highly vulnerable because of high risk and sensitivity. The appendices have useful information about the data sources for each of the indicators. It is quite useful to understand the approach.

ADB. 2009. ‘Climate Change and Its Impact: A Review of Existing Studies’ (Chapter 3), in The Economics Of Climate Change in Southeast Asia: A Regional Review. Asian Development Bank. Review on how the climate of SE Asia as a region (Indonesia, Philippines, Singapore, Thailand, Vietnam only) will change and how countries will be impacted. Some useful data, tables and figures relevant for IUWASH situational assessment. It explores how each sector in each country will be affected in general terms and highlights key vulnerabilities.

BAPPENAS. December 2009. Indonesia Climate Change Sectoral Roadmap (ICCSR): Synthesis Report. National Development Planning Agency, Republic of Indonesia. This report from Badan Perencanaan dan Pembangunan Nasional or BAPPENAS (National Development Planning Agency) is an excellent source of reliable climate change data, maps and graphs. The table ‘Activities of Long-Term Development Plan in Water Sector’ (p. 18) provides an action plan of priorities for climate change adaptation across Indonesia. There is a comprehensive mitigation component to the report. Developed with the help of GIZ, with contributions from most Indonesian ministries.

BAPPENAS. March 2010. Indonesia Climate Change Sectoral Roadmap (ICCSR): Water Resources Sector Report. National Development Planning Agency, Republic of Indonesia. This report, also from BAPPENAS, is another excellent source of reliable climate change data, maps and graphs. Some information in this report here is not found in the synthesis report, and vice-versa. This water resources sector report is particularly relevant because it discusses climate change’s impact on this sector; vulnerability assessments and, importantly, suggests adaptation strategies. Developed with the help of GIZ, with contributions from most Indonesian ministries.

Case, M., Ardiansyah, F. and Spector, E. 2007. WWF: Climate Change in Indonesia – Implications for Humans and Nature. Provides general climate change data and predictions for all sectors. Fairly general and brief on adaptation component, with greater detail on the natural environment (ecosystems, threatened species, etc.) than any other document found on CC in Indonesia.

Clifton, C., et al. 2010. Water and Climate Change: Impacts on groundwater resources and adaptation options. Water Working Notes 55027, note no. 25. Provides in-depth analysis on how groundwater resources are likely to be affected by climate change and why groundwater is such an important aspect of climate change adaptation. Very thorough discussion of specific adaptation options using solid case studies. Very helpful discussion of potential barriers and mistakes.

DNPI (National Climate Change Council). 2010. Climate Change Vulnerability in a Province (North Sumatra): Executive Summary. National Climate Change Council, Republic of Indonesia, Jakarta. This paper employs a different approach to the vulnerability assessments found in other literature. It contains very useful climate data and conclusions for the water sector. The Regional Vulnerability Indicator or Indicator of Cumulative Vulnerability (IKKR) has seven vulnerability indicators: number of poor people, access to clean water, population density, fraction of food crops area, fraction of plantation area, fraction of coastal area, and fraction of open area (non-cropped land). Cities are less vulnerable than districts because of higher adaptive capacity. In general, North Sumatra is ‘fairly vulnerable’ (cukup rentan), with Serdang Bedagai ‘highly vulnerable’. Five factors are described for adaptive capacity (IKKP): education, economy, road infrastructure, health and electricity. IKKR is combined with IKKP to become the coping capacity index (CCI). CCI is then combined with CCHI (extreme weather events), and the outcome is final vulnerability.

Downing, T. E. & Patwardhan, A. Technical Paper 3: Assessing Vulnerability for Climate Adaptation. UNDP. Provides a general overview on how to conduct vulnerability assessments in any part of the world.

Elliot, M., Armstrong, A., Lobuglio, J. and Bartram, J. 2011. Technologies for Climate Change Adaptation—The Water Sector. T. De Lopez (Ed.). Roskilde: UNEP Risoe Centre. Detailed summary of climate change adaptation options for the water sector. Identifies six ‘typologies’ (e.g., diversification of supply, conservation, etc.) of adaptation and then illustrates how each of the 11 listed adaptation practices/technologies relate to one or more of the six typologies. Highly informative sections on each of the CCA practices/technologies, including background and science, reasons why it is CCA, requirements, costing, etc.


Hidayat, F. October 2009. ‘Floods and climate change - observations from Java.’ Center for River Basin Organizations and Management, Solo, Central Java, Indonesia. CRBOM Small Publications Series No. 10. Provides observations on the recent increase in flood disasters in Java. Links flooding with watershed degradation and predicts climate change will add to this risk, but does not attempt to show the current contribution of climate change to this trend. Also provides general and brief section on flood adaptation strategies.


SME (KLH). 2010. Risk and Adaptation Assessment to Climate Change in Lombok Island, West Nusa Tenggara Province: Synthesis Report and Raw Water Sector Report. State Ministry of Environment, Republic of Indonesia, Jakarta. Assesses the vulnerability of Lombok to climate change and adaptation strategies. Useful data for that location (but limited data for localities of concern to IUWASH). Utilizes a simple framework of analysis that may be suitable for IUWASH to replicate, although requires a degree of complex modeling. Supported by GIZ.

Tearfund. March 2010. How to Integrate Climate Change Adaptation into National-Level Policy and Planning in the Water Sector: A practical guide for developing country governments. Provides an approach to integrating climate change adaptation into national-level policy and planning in the water sector in developing countries. Specifically looks at how to map other stakeholders and collaborate with them.
UN Water Policy Brief. June 2010. Climate Change Adaptation: The Pivotal Role of Water. Addresses water security as the central aim within successful climate change adaptation strategies. Stresses a ‘no regrets’ approach to climate change and an integrated approach to water resources management. Also provides an overview of mainstream development thinking in this field.


UNFCCC. 2007. Climate Change: Impacts, Vulnerabilities and Adaptation in Developing Countries. Provides a general overview of the impacts, vulnerabilities and adaptation to climate change in developing countries.

University of Gothenburg. September, 2008. Indonesia Environmental and Climate Change Policy Brief. A situational assessment of climate change impacts and responses in Indonesia, undertaken by Sweden for policy making. The document is broad in scope because it includes climate change mitigation and a discussion of impacts on all sectors. Also provides a summary of Indonesian policy environment and government stakeholders.

USAID. 2011. Water and Sanitation Sector Assessment for the Philippines. Chapter 7: Expected Impacts Of Climate Change On Water Supplies And Water Security. Prepared by DAI. Assessment for the Philippines of the impacts of each climate change parameter in general and then the impact on water resources specifically, due to different factors. A similar climate change situation is occurring in Philippines as in Indonesia, meaning that the report is highlight relevant to the Indonesian context. Gives practical and specific solutions for water sector, particularly in chapter 7. Favored approach is to help water planners to work on their own assessments of vulnerabilities and adaptive capacity. Report also includes an informative table outlining ‘no regrets’ actions vs. climate justified actions.
ANNEX B:
DRAFT SCOPE OF WORK WATER SUPPLY VULNERABILITY ASSESSMENT BASELINE STUDY

IUWASH Introduction

The Indonesia Urban Water Sanitation and Hygiene (IUWASH) project is a sixty-month program funded by the United States Agency for International Development (USAID) and implemented under the leadership of DAI. IUWASH works with government, the private sector, NGOs, community groups and other stakeholders to improve access to safe water supply and sanitation in Indonesia’s urban areas. The overall goal of IUWASH is to assist the Government of Indonesia (GOI) in making significant progress in achieving its safe water and sanitation Millennium Development Goal (MDG) targets by expanding access to these services. The expected results to be achieved are:
(a) Two million people in urban areas gain access to improved water supply; (b) 200,000 people in urban areas gain access to improved sanitation facilities; and (c) the per unit water cost paid by the poor in targeted areas decreases by at least 20%. To achieve the above, technical assistance is divided in three main technical components:

1. Mobilizing demand for water supply and sanitation service delivery;
2. Improving and expanding capacity for water and sanitation service delivery; and
3. Strengthening policy and the financial enabling environment for improved water supply and sanitation service delivery

One of the principal challenges currently faced by PDAMs and local governments in Indonesia is the availability and quality of the supply of raw water. A major cause of this problem is rapid land use change, which decreases the infiltration and storage capacity of the landscape and results in increased run off. Importantly, this condition will be—and in some ways already is—exacerbated by the negative impacts of climate change, which is expected to modify the duration and intensity of rainfall patterns.

An important aspect of IUWASH’s technical assistance package, then, is to help water utilities and their stakeholders better understand the unique vulnerabilities of their raw water supply and develop strategies to mitigate the risks posed by unsustainable land use practices and climate change. Towards this end, IUWASH has developed a four-step water resources vulnerability assessment and planning framework. The specific steps of the framework include: (1) a stock-taking/scoping of the current/known hazards facing the utility, (2) a climate change risk evaluation aimed at understanding how climate change may alter the nature of the hazards faced, (3) the development of a Climate Change Adaptation Plan, and (4) the implementation and monitoring of that plan.

Notably, the first step in this framework—the cataloguing and assessment of existing hazards facing the PDAM—requires the collection, organizing, and analysis of a significant amount of data regarding the local condition of raw water resources and the infrastructure that cleans and delivers this water to the population. Information required includes, for example, the hydrology/hydrogeology of springs and rivers that land use and topography within the
catchment area, major sources of run-off and contamination, and historic flood and drought patterns. Once collected,
this information will then allow for the development of a baseline risk scenario, as well as one to two “climate change
informed” risk scenarios. Ultimately, the development of these scenarios will lead to adaptation strategies to conserve,
protect, and enhance the utility’s raw water resources.

The purpose of this Baseline study, then, is to fulfill the first step of Climate Change Vulnerability Assessment (CCVA)
for the administrative area of XX District and nearby area of the borders district (bordering area with XX and
XX District), XX Province., Specifically, the Baseline study will focus on the springs and the raw water resources as
delineated in the current water supply plans of the PDAM XX and others raw water resources alternative.

(Map attached)

XX Background

Summary of following information:
- geological and hydrogeological conditions in district
- description PDAM raw water sources (historic and current)
- summary PDAM demand and supply balance
- issues related to water quality, potential for flooding, landslides, seawater intrusion
- problems / challenges with raw water sources currently used by PDAM
- future plan

To maintain and ensure the availability of raw water supply from the said rawwater sources, it is crucial for PDAM
XX to understand and develop action plans to protect and enhance these resources. While the precise causes of the
current decline in flow are unclear, a better understanding of the vulnerabilities is fundamental to their protection,
particularly in the face of the looming variable of climate change.

Plans for the protection and improvement of water resources, then, will require a complete Water Supply
Vulnerability Assessment Baseline Study for PDAM Kabupaten XX. The subcontracting organization (hereafter
referred to as the “Subcontractor”) will collect available information on the current conditions and potential threats
of the main water resource and water supply infrastructure of the PDAM. This information is expected to come
from a variety of sources, including a literature search, PDAM data, and other sources (BPDAS, BMKG, Department
of Mining and, and others). The study will also involve meetings with the PDAM and initial field visits during which
the Subcontractor will document current conditions through interviews, photographs, and, if possible, a one-time
measurement of spring and river flows and water levels from wells, as well as a measurement of water quality
parameters (pH, temperature, electrical conductivity, etc). GPS coordinates will also be collected for each site location.
In addition, available information on topography, geology, and field observations of the water resources catchment
areas, and water infrastructure will be incorporated into a geographical information system (GIS) with various layers
including a base map, topography, drainage basins, flood plains, etc.

The specific steps and outputs are described in detail in the following Scope of Work.

Purpose and Objectives:

The purpose of the “Baseline Study” is to collect, organize, and undertake a baseline analysis of available water supply
and climate data for PDAM Kabupaten XX. This information will ultimately be used to complete a climate change risk
evaluation and develop most appropriate adaptation strategies.
The following presents more detailed study objectives:

1. Obtain detailed data about water resources from surface and groundwater (springs, rivers and deep wells) in terms of quantity and quality for each PDAM raw water intake.

2. Obtain basic data and information of the geology, hydrology, hydrogeology, topography, land use, and pollution sources for each of the PDAM catchment areas.

3. Obtain of the recommends alternative raw water resources that potentially can be used by PDAM XX in the future, both located inside XX district and in the neighboring district(s).

4. Obtain data and information concerning the PDAM’s infrastructure, including clean water production, transmission and distribution pipelines, reservoirs, etc.

5. Obtain data and information on historic threats to the PDAM’s water resources and infrastructure, including flooding, landslides, salt water intrusion, storm surges and drought. This information will include (but is not limited to) the extent of damage, costs incurred by the PDAM, areas affected, and programs put in place by the PDAM to prevent damage from occurring in the future.

6. Identify data gaps in the basic data and make recommendations on possible follow-on measures to fill these data gaps to ensure and maintain the supply of raw water for the PDAM.

7. Conduct a review of existing climate change research, where available, for the PDAM’s service area.

The above data will be used by the Subcontractor to develop a completed picture of the historic and current threats facing the PDAM’s water resources and water supply infrastructure. Further, this information will then facilitate the development of plausible climate change impact scenarios.

**Relationship with the program IUWASH:**

This SOW will contribute to the achievement of the following IUWASH Outcomes:

- Component 2 (IC): Increase Capacity to Provide Sustainable Safe Water and Sanitation Services
- Outcome IC.4. Local government institutions implementing necessary climate change adaptation measures, based on raw water sources vulnerability assessments

**Detailed Tasks**

This Baseline Study is divided into six tasks defined as follows:

**Task 1: Work Plan Development**

**SoW:** Development of detailed work plan, including identification of responsible personnel and overall approach to the CCVA Baseline study

**Deliverable:** A detailed work plan

**Schedule:** To be completed within two weeks of contract signing

**LoE:** it will require estimated 4 mandays to complete this, including meeting(s) with IUWASH.

**Task 2: Literature Review**

**SoW:** A detailed literature review and data collection from sources such as PDAM XX BPDAS, BMKG, Mine and Energy Agency, the internet, academic institutions and others.
As a guide, Table 1 presents a check list for data collection.

**Deliverables:** A summary of data collection activities shall be presented to IUWASH staff for review. In addition, copies of all reports, names and details (title, address, email address, etc) of people contacted as well as a detailed reference list shall also be submitted to IUWASH.

**Schedule:** This task will be completed within the first month of the study.

**LoE:** It is anticipated that the data collection / literature search will take 10-15 man days.

### Task 3: Site Visits

**SoW:** An initial site reconnaissance trip will take place during which all springs, wells, and potential surface water resources (rivers, lakes, etc.) will be visited. During these visits, GPS coordinates, photos, baseline flow/water level measurements, as well as field water quality measurements (pH, temperature, and specific conductance) will be taken and recorded. In addition, available data, distribution system maps, and other information will be gathered from the PDAM and the data collection check list will be updated. Further, the team will interview local farmers concerning changes that they noticed in water availability in watersheds that affect PDAM facilities.

**Deliverables:** For site visits, a photo log and a day by day trip report will be presented. In addition, at the completion of the site visit, a “Data Gap” report will be provided to IUWASH identifying data gaps and information limitations towards completing remainder of Baseline study. The data collection report from Task 2 will also be updated. All data will be placed in an Excel Spreadsheet or Access Database and copied to IUWASH.

**Schedule:** Site visits will take place from week 4 to week 7 of the study.

**LoE:** Estimated labor allocation for this Task is 40 man-days.

### Task 4: Data Organization, Review, and Analysis

**SoW:** A review and analysis of available water resources data for XX District, including (1) spring raw water resources, (2) Surface raw water resources, and (3) Groundwater raw water resources. Specific sub-tasks are as follows:

- Review and analysis of available discharge and water quality data for all springs, surface water and deep wells utilized by the PDAM within the study area.
- Evaluate precipitation data and determine relationships to water levels in wells, surface water flow, and spring.
- Perform trend analysis with data available to predict future flow and quality including low flow conditions, runoff coefficients, recharge and discharge characteristics.
- Identification of existing/potential threats to water resources including the type, location and magnitude of the threat. These threats may be due to landslides, pollution, changes in land use (deforestation, urban development, etc.).
- General analysis of local climate and hydrogeological conditions for Kabupaten XX, and, specifically, for each of the spring catchment areas used as PDAM raw water resource, including anticipated climate change variables.
- Topographical analysis based on existing maps for each PDAM spring catchment area. This includes drainage divides, average slopes, areas of landslide potential, etc.
- Analysis of conditions, allocation, and land use for each PDAM spring catchment.
- Geological and hydrogeological conditions of district Kabupaten XX catchment(s), especially for catchments related to each of springs, including the study of nature and characteristics of rocks and geological potential threats or natural disasters.
- Review local government agencies responsible for local regulations and analysis of the current regulations related to raw water protection, water rights, of take agreements
- Review of local government agencies responsible for budget provision for water resource protection activities.
• The review and analysis of the PDAM infrastructure, including:
  o Review of historic flooding, landslides, drought and other events that may have caused
damage to PDAM facilities; information on damage caused and economic costs to
PDAM in terms of clean-up, repair, replacement and loss of service.
  o Analysis of the potential and opportunities of institutional arrangements regarding use of
water resources across regions (regionalization of water resources).
  o General analysis of future water resource requirements for PDAM considering coverage
targets, estimated population growth, water demand scenarios for 10 - 20 years.
  o Assessment of the PDAM future development plans.
  o Develop baseline PDAM supply and demand curves for next 20 years (assuming a static
cclimate), highlighting periods where demand is expected to exceed supply.

Deliverables: Results of analysis to be presented in the Final Report as delineated in Task 6.
However, once initiated monthly progress reports will be delivered to IUWASH.
Schedule: Start after completion of Task 3 – Site Reconnaissance for a period of 5 weeks.
LoE: Anticipated level of effort for this task is 40 man-days

Task 5 Geographical Information System Evaluation
SoW: During this task, maps and analyses will be developed using GIS, using layers on a base map so that a
series of maps can be developed showing:
  1. Water sources (wells, springs and surface water) incl catchment areas
  2. Topography
  3. Geology/hydrogeology
  4. Land-use
  5. Basic demographic data, including population density and poverty levels
  6. Water transmission, production, and distribution system
  7. 100-yr flood plain (based on topography).
  8. Location of historical landslides, pollution sources, and prone to drought, fires, etc.

Deliverables: GIS system files and related data
Schedule: Done concurrently with Task 3 and 4 and completed 12 weeks after project start up.
Progress of this task should be included in the monthly progress reports for the project.
LoE: Anticipated that the level of effort for this Task is 30 man-days

Task 6: Draft and Final Report
SoW: Based on results of Task 1-5, a draft report will be issued to IUWASH for review and once reviewed
be finalized. Final report shall cover the following topics
  1. A complete description of available data and information available from literature available and
other sources including a complete bibliography.
  2. A detail discussion of data review and analysis including:
     a. Description of the PDAM and utilization of raw water resources including:
        i. Current PDAM structure, treatment and distribution system
        ii. Supply and demand (% served, industrial usage, and other water users)
        iii. Historic water supply problem areas
        iv. Future development plans
     b. Physiography of the XX District (topography, geomorphology, and land use)
     c. Meteorology (long-term precipitation and temperature trends)
     d. Hydrogeology
        i. Nature and extent of aquifers
        ii. Recharge and discharge (locations of springs, catchments/recharge areas)
iii. Available data of usage, water levels, and flows
iv. Water quality
v. Threats to flow & quality (pollution, land use change, overpumping)

**e. Hydrology**

i. Location of surface water bodies (rivers, lakes, etc.)
ii. Catchment area descriptions (topography, land use, pollution sources)
iii. Flow (hydrographs and statistical analysis)
iv. Runoff coefficients
v. Usage (current and future)

**f. Regional Climate Change Background**

i. Anticipated changes to precipitation and temperature based on available information for service area (literature reviews, interviews)
ii. Potential impacts to raw water supply and PDAM infrastructure

**g. Conclusions and Recommendations**

i. Identification of data gaps
ii. General conclusions and recommendations on potential activities which could be considered in PDAM action plans
iii. Additional information required for these action plans to take into account climate change.
iv. Preparation of PowerPoint presentations on findings and conclusions

**Deliverables:** A draft and final report

**Schedule:**
- The draft final report will be due 14 weeks after startup of the project.
- The final report will be due 16 weeks after startup of the project.

**LoE:** Anticipated level of effort for this task is 30 man-days.

### Document Deliverables:

The following table presents a summary of deliverables to be provided by the consultant, due dates, and payment schedule for the six (6) sets of deliverables described above:

<table>
<thead>
<tr>
<th>Deliverable Description</th>
<th>Due Date</th>
<th>Payment Schedule (% of contract value)</th>
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<tr>
<td>Deliverable I: Work Plan (Inception Report)</td>
<td>End of Week 2</td>
<td>40%</td>
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<tr>
<td>Deliverable II: Data Collection Summary</td>
<td>End of Month 1</td>
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<tr>
<td>Deliverable III Site Visit Report and Data Gap Analysis</td>
<td>End of Month 2</td>
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<tr>
<td>Deliverable IV: Progress Report Data Collection Results</td>
<td>End of Month 3</td>
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<tr>
<td>Deliverable V: Draft Final Report</td>
<td>End of Week 2nd week Month 4</td>
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<tr>
<td>Deliverable VI: Final Report (Final report)</td>
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**Time Schedule of Study:**

Baseline study will be conducted during 5 months period between XX to XX, 2012.

<table>
<thead>
<tr>
<th>No</th>
<th>Activity</th>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
<th>Month 4</th>
<th>Month 5</th>
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<tr>
<td>1</td>
<td>Task 1 Work plan</td>
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<td>Work plan</td>
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<td>2</td>
<td>Task 2 Literature review</td>
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<td>Site visits</td>
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<td>3</td>
<td>Task 3 Site visits</td>
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<td>Data review</td>
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<td>Task 4 Data review</td>
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<td>GIS Evaluation</td>
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<td>Task 5 Draft final report</td>
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<td>Final report</td>
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<td>6</td>
<td>Task 6b Final report</td>
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Note: ★ = payment period

**Parties Involved:**
- IUWASH National and Regional teams
- PDAM XX management and technical teams (as beneficiaries)
- PEMDA XX (Bappeda, PU Dis, Dishutbun, BPLHD, Perhutani, Distamben, etc.)
- Communities in/around water catchment areas
- Local institutions, NGO, Universities, etc.

**Requirement for study team:**
To carry out this Baseline study a team is required with sufficient variety of expertise and experience. Specifically, the Subcontractor shall provide a team of three to five persons with expertise in hydrology, geology, environmental engineering, geographic information systems, and economics. Additionally, the Subcontractor shall designate one member as the Team Leader, who will maintain the overall responsibility for the accomplishment of the above deliverables and act as the principal point of contact for IUWASH. The Team Leader is expected to possess a minimum of 10 years of experience in one of the above disciplines, including experience in the management and supervision of teams.

**Budget estimate:**
IUWASH estimates a budget ranging from IDR xx million.
### ANNEX C: ILLUSTRATIVE CLIMATE CHANGE ADAPTATION OPTIONS FOR THE WATER SECTOR

<table>
<thead>
<tr>
<th>Adaptation Categories</th>
<th>Specific Responses</th>
<th>Drought</th>
<th>Flood</th>
<th>Landslide</th>
<th>Sea Level Rise</th>
<th>Included in IUWASH SOW</th>
<th>No Regrets Option</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source Water Protection</strong></td>
<td>- Watershed Protection: Establishment of protected zones critical for water recharge, spring protection, or riparian preservation</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
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<td>- Improved regional water resources governance through establishment of water governance bodies (i.e. watershed management committees)</td>
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<td>- Strengthened regulatory environment, including groundwater and surface water extraction permits</td>
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<td>■</td>
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<td>✓</td>
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<tr>
<td></td>
<td>- Aquifer recharge programs and technologies (managed aquifer recharge)</td>
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<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Farmer extension programs aimed at reducing soil erosion and nutrient loading</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Improved wastewater collection and treatment and solid waste management</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Multi-stakeholders forums of upstream users to avoid conflicts for limited resources resulting in damage to property</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Payment for Environmental Services</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Water Demand Management / Efficiency</strong></td>
<td>- Non-Revenue Water Reduction, including leak detection, management and repair</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Water meter maintenance and replacement</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Efficient water pricing (i.e. increasing block tariffs)</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Social marketing for consumer behavior change</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Energy Efficiency measures to maintain service provision with reduced energy costs</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Consumer incentive programs to install efficient, low-flow devices, fixtures, and appliances.</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Wastewater reuse/recycling for agriculture and industry</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Infrastructure Options</strong></td>
<td>- Check dams to slow runoff and facilitate aquifer recharge</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Rainwater harvesting systems at the community level.</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>- Diversify water resources through construction of deep wells, new surface water intakes, inter-basin transfers, and desalination</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Adaptation Categories</td>
<td>Specific Responses</td>
<td>Drought</td>
<td>Flood</td>
<td>Landslide</td>
<td>Sea Level Rise</td>
<td>Included in IUWASH SOW</td>
<td>No Regrets Option</td>
</tr>
<tr>
<td>-----------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>---------</td>
<td>-------</td>
<td>-----------</td>
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<td>------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>Infrastructure Options (cont.)</td>
<td>Increase access to improved urban sanitation systems to reduce pollution of upstream water sources and local groundwater</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Expanded wastewater treatment for water reuse in agriculture and industry</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expand/upgrade urban drainage systems</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Increase storage capacity (reservoirs, artificial lakes, etc.)</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Construction of berms, dikes, or sea walls</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Relocation / strengthening water infrastructure subject to flooding, including raising pumping stations and well heads, constructing aprons for bore-wells.</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planning and Information Management</td>
<td>Water Allocation Decision-Support Systems (including forecasting tools for water resources)</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Installation of Hydrological / Meteorological / Groundwater Monitoring Stations</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Compilation and organization of historical climate date</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Downscaling General Circulation Models to the local level</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water resources research to, for example, better understand and map the location and characteristics of aquifers.</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Disaster Early Warning Systems</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Disaster Management Plans</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Water Safety Plans</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Risk Transfer</td>
<td>Purchase of property insurance for buildings and other key assets (i.e. vehicle fleet)</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Establishment of government disaster reserve fund</td>
<td>■</td>
<td>■</td>
<td>■</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

Sources:
ANNEX D: EXAMPLE OF MULTI-CRITERIA ANALYSIS

MCA provides a decision-making framework by utilizing quantitative and/or qualitative criteria to assess and compare impacts (Cabot Ventron, 2012). The below table—taken from the Water and Sanitation Sector Assessment in the Philippines (DAI, 2011)—provides an example of how MCA may be utilized to begin to identify adaptation options. The below example classifies options within two adaptation categories (protecting water quality and water use efficiency) according to technical, financial, institutional, and political acceptability. The options could then be ranked by, for example, converting the ratings to numeric scores (i.e. 1, 2, 3) and summing the overall scores.

<table>
<thead>
<tr>
<th></th>
<th>Technical Complexity</th>
<th>Financial Complexity</th>
<th>Institutional Complexity</th>
<th>Political Complexity</th>
<th>Regret</th>
<th>Institutions for Action</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protecting Water Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strengthen the Clean Water Act requirements on wastewater discharge</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>No regret</td>
<td>DENR/EMB, NWRB, Congress</td>
</tr>
<tr>
<td>Improve water quality monitoring—ground and surface</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No regret</td>
<td>DENR, DOH, water service provider</td>
</tr>
<tr>
<td>Restrict development in important water catchments</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium to High</td>
<td>No regret</td>
<td>Provincial LGUs, LGUs and DENR</td>
</tr>
<tr>
<td>Reforest degraded watersheds</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>No regret</td>
<td>DENR, PLGUs and LGUs</td>
</tr>
<tr>
<td>Protect riparian zones</td>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>No regret</td>
<td>LGUs, LGUs, and DENR</td>
</tr>
<tr>
<td>Institute and enforce polluter pays principals to protect water quality</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
<td>No regret</td>
<td>DA, DENR/EMB</td>
</tr>
<tr>
<td>Establish payments for environmental services to upstream land/resource users to protect watersheds</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>No regret</td>
<td>Water service providers, NGOs and Provincial LGUs</td>
</tr>
<tr>
<td>Expand declared protected areas</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>No regret</td>
<td>DENR, Congress</td>
</tr>
<tr>
<td><strong>Improve Water Use Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduce NRW by Water service providers</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>No regret</td>
<td>Water service providers</td>
</tr>
<tr>
<td>Meter all customers</td>
<td>Low</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
<td>No regret</td>
<td>Water service providers</td>
</tr>
<tr>
<td>Adjust tariffs to promote greater efficiency</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>No regret</td>
<td>Water service providers</td>
</tr>
<tr>
<td>Consumer behavior change/social marketing programs and promotion of water efficient/low flow appliances</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
<td>No regret</td>
<td>Water service providers</td>
</tr>
<tr>
<td>Replace outdated networks</td>
<td>Medium</td>
<td>Complex</td>
<td>Low</td>
<td>Medium</td>
<td>Climate justified</td>
<td>Water service providers</td>
</tr>
</tbody>
</table>
ANNEX E:
WATER SUPPLY VULNERABILITY ASSESSMENT AND ADAPTATION PLAN: UTILITY REPORT OUTLINE

The below outline describes the key sections and subsections of the Vulnerability Assessment and Adaptation Plan that will be prepared as a result of the implementation of the VAAP Framework. This report integrates the results of the Baseline Study (prepared by a third party), stakeholder consultations, and the workshops with PDAM operators and decision-makers. The report will be prepared in Bahasa Indonesia.

(1) Introduction:
   a) Introduction to IUWASH
   b) Overview of purpose and scope of document
   c) Description of VAAP Framework (Methodology)

(2) Current Water Resources Situation:
   a) PDAM Background: Description of current system, types of water resources, historical hydro-met data, customer data, and supply/demand projections;
   b) Baseline Scenario Vulnerability Assessment: Identification of existing hazards and evaluation of associated risks.
      • Geospatial Analysis: Mapping of current risks, including land use, flood patterns, and landslide risks
      • PDAM Asset Risk Matrix: Analysis of risks to key PDAM assets

(3) Climate Change Vulnerability Assessment:
   a) Analysis and synthesis of localized climate change data using existing research, interviews, and models;
   b) Climate Change-Driven Scenario Vulnerability Assessment: Considering how the PDAM’s risk profile may change.
      • Geospatial Analysis: Mapping potential future risks, including changing land use, new flood patterns, greater coastal inundation due to seal level rise, and landslide risks.
      • PDAM Asset Risk Matrix: Analysis of how risk levels may change under a moderate or high climate change scenario.

(4) Adaptation Planning:
   a) Introduction to purpose and approach to adaptation planning.
   b) Long-list of supply side and demand side adaptation options, including brief comments on the advantages/disadvantages of each.
   c) Short-listing of adaptation options. Description of process with stakeholders, criteria used (i.e. cost/benefit, politically acceptable, number of external approvals required, etc.), and resulting shortlist.
   d) Review and prioritize options.

(5) Conclusion:
   a) Immediate actions and assignment of responsibility for implementation.
   b) Approach to integrate results into key PDAM/LG planning documents such as Corporate Plan.